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VOLUME 13 MAY, 1939 NUMBER 3

SILURIAN FOSSILS FROM NORTHERN NEWFOUNDLAND

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ABSTRACT—Silurian fossils from localities in Notre Dame and White Bays are described and illustrated. The total fauna includes 1 alga, 23 coelenterates, 1 annelid, 1 bryozoane, 21 brachiopods, 1 pelecypod, 1 cephalopod, 5 trilobites and 1 ostracode. One new genus and species of algae, 2 new species of corals, 5 new species of brachiopods and 3 new species of trilobites are described. The fauna has a community of stratigraphic characteristics and is correlated with that of the Jupiter formation of Anticosti and the Ross Brook (Arisaig) of Nova Scotia. Farther afield the fauna correlates with the Clinton of New York and the Middle Llandovery of England. The fossils show that the Silurian strata of northern Newfoundland were deposited in the Appalachian geosyncline.

THE EARLIEST reference to Silurian fossils in Newfoundland was made by Murray (1881, p. 40) in 1865, when he reported several Silurian species from White Bay. Later (1872) Murray and Howley (1881, pp. 270–271) reported a number of species from Goldson Arm, New World Island, and a few other localities. Schuchert and Dunbar (1934, p. 103) listed Silurian fossils in the collections of the Geological Survey of Newfoundland and identified by Schuchert in 1910. Twenhofel and Shrock (1937) gave a provisional list of Silurian fossils found by them and by recent expeditions from the Geological Survey of Newfoundland and from Princeton University; and Heyl (1937, 1937a) included in his recent reports on the Silurian of White Bay a number of species identified for him by W. H. Twenhofel and described more fully in the present report.

Most of the fossils described and illustrated in this report were collected by the writers in the summers of 1935 and 1936. The expedition of 1935 was supported by the Grants-in-Aid Committee of the National Research Council, and that of 1936 (made by W. H. Twenhofel, only) in part by the Geological Survey of Newfoundland. This assistance is gratefully acknowledged. Drs. A. K. Snelgrove and G. R. Heyl very kindly made available for study all Silurian fossils collected by the various expeditions made by the Geological Survey of Newfoundland and by the staff of the Department of Geology of Princeton University. The collections made by Murray and Howley, and studied by Schuchert in 1910, apparently are no longer in existence. The photographic work of this report was partly financed by a grant from the Wisconsin Alumni Research Foundation and publication costs were met in part by a grant from the Geological Survey of Newfoundland.

GEOLOGIC SECTION

The stratigraphic section of Silurian strata of Notre Dame Bay, in descending order, is as follows (Twenhofel and Shrock, 1937):

SECTION OF NOTRE DAME SERIES (SILURIAN) ON NOTRE DAME BAY

Unnamed limestone:

Fossiliferous gray crystalline limestone in flow breccias on Upper Black Island, containing an abundance of *Stricklandinia exploitensis* Shrock and Twenhofel, n. sp. This limestone is thought to be younger than the Pike Arm formation.

Contact relations unknown.

Pike Arm formation:

Dark-colored coralline argillites, black fossiliferous argillites, and barren gray and pink sandstones. These rocks are well exposed in Goldson and Pike Arms, New World Island, and on Yellow Fox Island south of the Indian Islands.

Apparently conformable.

Goldson formation:

Thick- and heavy-bedded conglomerates containing thin lenses of hard and tough bluish-gray argillaceous, siliceous limestone. Fossils occur mainly in the lenses but infrequently in the body of the conglomerate. The sequence is well exposed in Goldson Arm and Herring Head, New World Island, and on Martin Eddy Point near the mouth of the Exploits River.

Contact relations unknown, seemingly conformable.

Botwood formation:

Thin-bedded, ripple-marked, and cross-laminated gray to pink fine-grained sandstones and quartzites interbedded with thin argillites. The only fossils noted are echinoderm columnals and poorly preserved brachiopods. The formation is well exposed between Peter Arm and the lower reaches of the Exploits River south of Botwood, and on the southern half of Change Island.

Contact relations with underlying rock unknown.

The White Bay section has been described recently by Heyl (1937, 1937a). The writers have recently identified Silurian fossils collected by Heyl from a metamorphosed limestone in Besom Cove and Northwest Arm of New Bay, Notre Dame Bay. The limestone formation has not yet been named, but the fauna is described below. Other Silurian strata in northern Newfoundland, on Exploits River at Bishop Falls and at Grand Falls, contain so few organic remains that the sections are omitted.

Generally the strata in the sections just mentioned are relatively unfossiliferous and are more or less metamorphosed. Metamorphism, however, can not fully explain the absence or paucity of fossils, and it seems probable that many of the sediments contained few organic remains at the time of lithification.

FOSSIL LOCALITIES

Fossils have been collected at the following localities (see figs. 1–3), which are listed under the several formations:

Unnamed limestone.—Gray, coarsely crystalline limestone lenses in flow breccia on Upper Black Island in Bay of Exploits.

Pike Arm formation.—1. Fossil Point, a small peninsula which projects into Pike Arm from the southeast shore (at very high tide the outer part is an island) about one-fourth mile east of the canal between Pike and Herring arms. There are three fossiliferous zones, designated *outer* and *inner coral zones* and *fossiliferous argillite* (fig. 3).

2. Burnt Island, a small island in Goldson Arm, New World Island. Two fossiliferous zones are present; a gray *coralline argillite* and a *black argillite*. Echinoderm columnals are also present in some of the sandstones, and poorly preserved fossils occur in much-fractured argillite exposed in a small fault block at the extreme southwestern tip of the island (fig. 2).

3. Yellow Fox Island, a small island south of the Indian Islands. The fossils are greatly deformed and occur in pebbly sandstone or in argillite.

Goldson formation.—1. Martin Eddy Point, on the left bank of Exploits River, about three miles upstream from the mouth. Fossils occur in bluish-gray argillaceous and calcareous lenses and in the general matrix of a conglomerate.

2. Southeast shore of Goldson Arm, where fossils occur in the matrix of a conglomerate and in tough calcareous lenses.

3. Small island at the head of Goldson Arm, where a few fossils occur in a conglomerate.

Botwood formation.—A few echinoderm columnals were collected from pink and gray sandstones in the southern half of Change Island.

Natlins Cove formation.—The several

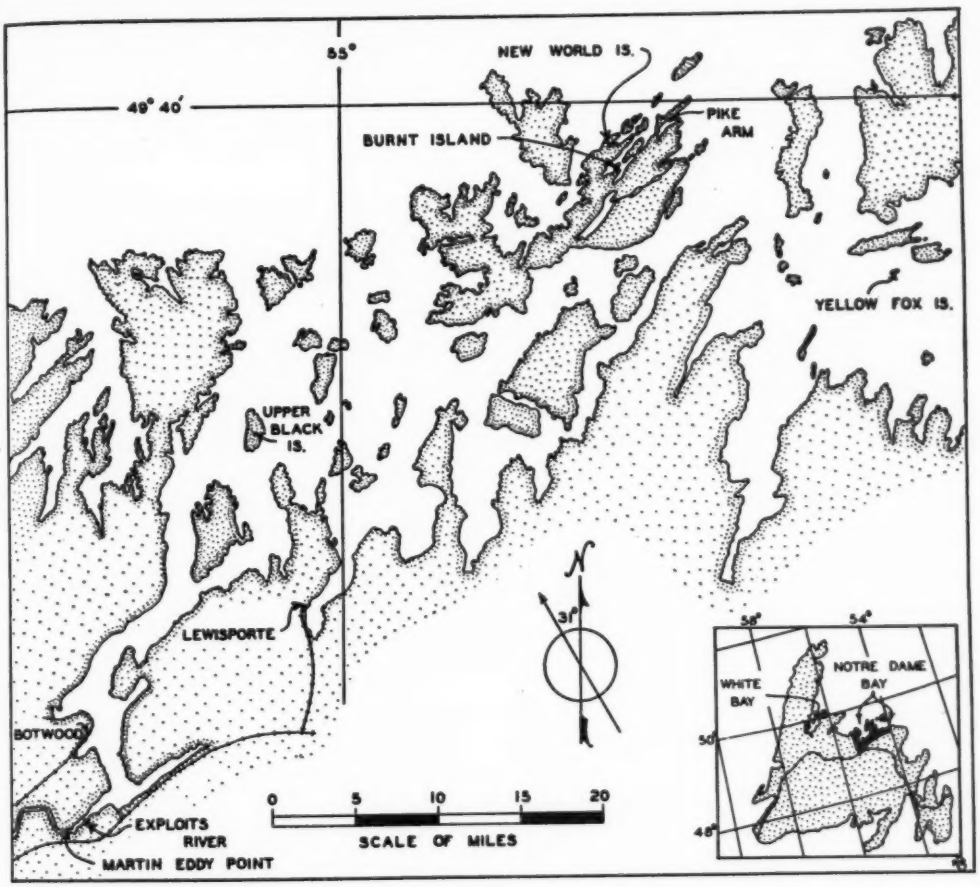


FIG. 1.—Map of a portion of Notre Dame Bay, northern Newfoundland, showing the location of several fossiliferous localities. Small insert map shows the general location of Notre Dame and White Bays. Map based on United States Hydrographic Office Chart No. 1101 (1923).

fossiliferous localities of this formation in White Bay (Sops Arm and Jacksons Arm) are fully described in Heyl's (1937a) recent report.

Unnamed limestone.—Fossils occur in reefy and fine-grained limestones in Besom Cove and Northwest Arm of New Bay, Notre Dame Bay. This limestone was investigated in 1937 and has not yet been named.

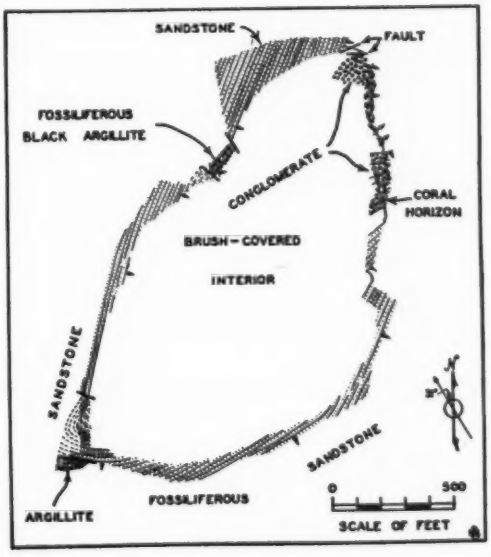


FIG. 2.—Sketch map of Burnt Island in Goldson Arm, New World Island (See Fig. 1), showing location of the two fossiliferous localities. Map based on a Brunton-pacing traverse.

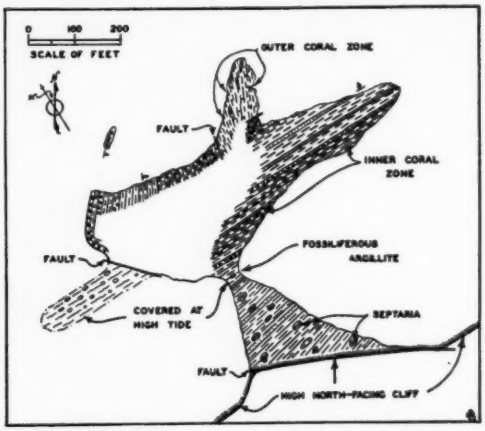


FIG. 3.—Sketch map of Fossil Point, Pike Arm, New World Island (See Fig. 1), showing location of the three fossiliferous localities. Map based on a Brunton-pacing traverse.

PRESERVATION OF FOSSILS

Many of the Newfoundland fossils are so poorly preserved that identification is difficult and in many cases impossible. This is due largely to the alteration which the containing strata have suffered. In some instances coralla of *Favosites* and colonies of *Clathrodictyon*, originally four inches or more high and six or more in diameter, have been spread into thin sheets less than half an inch thick but a foot or more in diameter. This spreading usually destroyed the more delicate parts of large specimens and completely destroyed small, delicate forms, particularly if they were contained in coarse-grained argillites and sandstones. Small fossils escaped destruction or much distortion in a few localities, as in the Goldson conglomerate in Goldson Arm and at Martin Eddy Point on Exploits River, and in the coral zones of the Pike Arm formation on Burnt Island in Goldson Arm and Fossil Point in Pike Arm. Where contained in black argillites, small fossils are commonly distorted. Fossils originally present in the Natlins Cove formation of White Bay have been largely destroyed by metamorphism.

AGE OF THE FOSSILS

The known Silurian fossils of northern Newfoundland, although collected from several horizons, show a community of stratigraphic characters, and the containing strata are correlative with the Jupiter River formation of Anticosti, the Ross Brook formation of the Arisaig section in Nova Scotia, and the Clinton beds of the United States. Across the north Atlantic the fossiliferous Silurian of northern Newfoundland is roughly correlative with the Middle Llandovery.

PALEOECOLOGY INDICATED BY THE FOSSILS

Although the Newfoundland fossils are confined to one general stratigraphic position, those of the different lithologies are not alike. For instance, all of the identifiable fossils in the limestone blocks from Upper Black Island belong to a single species of *Stricklandinia*, which is not present elsewhere. Corals are abundant in calcareous argillites on Burnt Island, Goldson Arm, and on Fossil Point, Pike Arm; but are uncommon in black argillites, which, however, contain many brachiopods, mollusks and arthropods. This difference is particularly interesting since the two lithologies are separated by only a short distance stratigraphically.

Conditions on the bottoms of the Botwood sea appear to have been unfavorable for the preservation of most organisms, as only a few echinoderm columnals have been found in spite of the fact that there are places where the sandstones have suffered very little metamorphism. Evidence indicates that there were numerous organisms on the bottoms where the Goldson conglomerates accumulated, and the presence of *Pentamerus oblongus* and corals suggests clear water. *Stricklandinia* lived in profusion on the bottoms where the pure limestones of Upper Black Island were deposited, but why corals and other lime-loving organisms did not live in the same environment is not clear.

DESCRIPTION OF SPECIES

An attempt has been made to describe and illustrate most identifiable species. This is considered justifiable since all previous references have been limited to tentative identifications.

All descriptions except those of the brachiopods and a few species of other groups were originally written by the first

FOSSILS FROM THE SILURIAN STRATA OF NORTHERN NEWFOUNDLAND

G—Goldson formation
P—Pike Arm formation
L—Limestone blocks in flow breccia on Upper Black Island
l—Limestones in New Bay
N—Natlins Cove formation

	Martin Eddy Point, Exploits River	Wigwam Point, Exploits River	S. E. Shore: Goldson Arm	Small Island: Goldson Arm	Fossil Point: Outer coral	Fossil Point: Inner coral	Fossil Point: Foss. argillite	Burnt Island: Coralline argillite	Burnt Island: Black argillite	Yellow Fox Island	Upper Black Island	Localities in New Bay	Localities in White Bay
Algae													
Goldsonia burntensis, n. gen., n. sp.	—	—	—	—	—	—	—	—	P	—	—	—	—
Coelenterata													
Clathrodictyon vesiculosum	G	—	—	—	P	P	—	P	—	P	L	l	N
Cladopora newfoundlandensis, n. sp.	—	—	—	—	—	—	—	—	—	—	—	—	N
Coenites labrosus	—	—	—	—	—	—	—	P	P	—	—	—	—
Cyathophyllum articulatum	—	—	—	—	P	P	P	P	—	P	—	—	—
Cystiphyllum niagarense	—	—	—	—	—	—	—	—	—	—	—	l	—
Cystiphyllum pikense, n. sp.	—	—	—	—	P	—	—	—	—	—	—	—	—
Diphyphyllum multicaule	—	—	—	—	—	—	—	—	—	—	—	l	—
Enterolasma caliculum	—	—	—	—	P	—	—	—	P	—	—	l	—
Favosites favosus	—	—	—	—	—	—	P	—	—	—	—	—	—
Favosites forbesi	—	—	—	—	P	—	—	—	—	—	—	—	—
Favosites gothlandicus	—	—	—	G	P	P	—	P	—	P	—	l	N
Favosites hisingeri	G	G	G	G	P	P	—	P	—	P	—	l	N
Halysites catenularia	—	—	—	—	P	P	—	P	P	—	—	l	N
Halysites catenularia microporus	—	—	—	—	P	—	—	—	—	—	—	—	—
Heliolites interstinctus	G	—	—	—	P	—	—	P	P	—	—	l	N
Heliolites subtubulatus	—	—	—	—	P	—	—	P	—	—	—	—	—
Lyellia affinis	—	—	—	—	—	P	—	P	—	—	—	l	—
Lyellia americana	—	—	—	—	P	—	—	—	—	—	—	—	—
Lyellia decipiens	—	—	—	—	P	—	—	—	—	—	—	—	—
Lyellia exigua	—	—	—	—	—	P	—	—	—	—	—	l	—
Lyellia superba	—	—	—	—	P	P	—	P	—	—	—	—	—
Strombodes (Arachnophyllum) diffluens	—	—	—	—	—	—	—	—	—	—	—	l	—
Zaphrentis stokesi	—	—	—	—	P	P	—	P	—	P	—	l	—
Annelida													
Cornulites serpularius	—	—	—	—	—	—	—	—	P	—	—	—	—
Bryozoa													
Hallopora elegantula	—	G	—	—	—	—	—	—	—	—	—	—	—
Brachiopoda													
Atrypa reticularis	G	—	G	—	P	—	—	—	P	—	—	—	—
Brachyprion elegantulum	—	—	—	—	—	—	P	—	—	—	—	—	—
Brachyprion leda	—	—	—	—	—	—	P	—	—	—	—	—	—
Brachyprion robustum	—	—	—	—	—	—	P	—	—	—	—	—	—
Choneles exploitensis, n. sp.	G	—	—	—	—	—	—	—	—	—	—	—	—
Coelospira hemispherica	?	—	—	—	—	—	P	P	P	—	—	—	—
Dolerorthis flabellites	—	—	—	—	P	—	—	P	—	—	—	—	—
Eospirifer radiatus	—	—	—	—	—	—	P	P	—	—	—	—	—
Leptaena rhomboidalis	—	—	—	—	P	—	—	—	—	—	—	—	—
Lissatrypa atheroidea	G	—	—	—	—	—	—	—	—	—	—	—	—
Mendacella uberis	G	—	—	—	—	—	—	—	—	—	—	—	—
Orbiculoidea pikensis, n. sp.	—	—	—	—	—	—	P	—	—	—	—	—	—
Parmorthis elegantula	G	—	—	—	—	—	P	—	P	—	—	—	—

FOSSILS FROM THE SILURIAN STRATA OF NORTHERN NEWFOUNDLAND—*Continued*

G—Goldson formation
P—Pike Arm formation
L—Limestone blocks in flow breccia on Upper Black Island
l—Limestones in New Bay
N—Natlins Cove formation

	Martin Eddy Point, Exploits River	Wigwam Point, Exploits River	S. E. Shore: Goldson Arm	Small Island: Goldson Arm	Fossil Point: Outer coral	Fossil Point: Inner coral	Fossil Point: Foss. argillite	Burnt Island: Coralline argillite	Burnt Island: Black argillite	Yellow Fox Island	Upper Black Island	Localities in New Bay	Localities in White Bay
Pentamerus oblongus	G	G	—	—	—	—	—	—	—	—	—	—	—
Plagiorhyncha decemplicata	—	—	—	—	—	—	P	—	—	—	—	—	—
Rhynchotreta cuneata americana	G	—	—	—	—	—	—	—	P	—	—	—	—
Schuchertella alterniradiata	—	—	G	—	—	—	—	—	—	—	—	—	—
Sowerbyella cf. *transversalis*	—	—	—	—	—	—	P	—	—	—	—	—	—
Stricklandinia exploitensis, n. sp.	—	—	—	—	—	—	—	P	—	—	L	—	—
Stricklandinia newfoundlandensis n. sp.	—	—	—	—	—	—	P	—	—	—	—	—	—
Zygospira? exploitensis, n. sp.	G	—	—	—	—	—	—	—	—	—	—	—	—
Pelecypoda													
Pterinea emacerata	—	—	—	—	—	—	—	—	P	—	—	—	—
Cephalopoda													
Kionoceras bellatulum	—	—	—	—	—	—	—	—	P	—	—	—	—
Trilobita													
Calymene niagarensis	—	—	—	—	—	—	—	—	P	—	—	—	—
Dicranopeltis norrisensis, n. sp.	G	—	—	—	—	—	—	—	—	—	—	—	—
Encrinurus anticostiensis	G	—	—	—	P	—	P	P	P	—	—	—	—
Eophacops newfoundlandensis, n. sp.	G	—	—	—	—	—	P	—	P	—	—	—	—
Goldius newfoundlandensis, n. sp.	—	—	—	—	—	—	—	—	—	—	—	l	—
Ostracoda													
Leperditia cf. *L. selwyni*	—	—	—	—	—	—	—	—	P	—	—	—	—

author, later revised by the second, and finally rewritten by the two in conference. All other descriptions were originally written by the second author, revised by the first, and rewritten in conference. All photographic work was done by the first author.

It should be noted that the list of fossils that have been identified from the Silurian strata of northern Newfoundland does not include several species reported by other geologists who had an opportunity to study the original collections of the Newfoundland Geological Survey. Some of these identifications will be noted. *Zaphrentis bellistriata* is an Ordovician coral found in the Ellis Bay formation of Anticosti and hence not likely to be present in the Newfoundland Silurian. *"Dalmanella" ruida*, from the Ellis Bay and basal strata of the overlying Becsie formations, is not likely present. *Sowerbyella* (*Plectambonites*) *sericeus* is an Ordovician brachiopod. *Atrypa marginalis* was identified by Schuchert and may well be present, though the writers did not find it. *Hebertella maria*, also identified by Schuchert, is a Richmond form, and it does not seem likely that it is present in the Newfoundland Silurian.

So far as the material permitted, duplicates of the species obtained by the writers have been placed in the collection of Newfoundland fossils at Princeton University. The types of the new species now reside in that collection or in the private collection of W. H. Twenhofel.

In the following descriptions bibliographic references usually are not given, but when they are they will refer to an article

in which a particular species is well described and illustrated. Synonymies complete to 1915 will be found in Bassler's "Bibliographic Index of American Ordovician and Silurian Fossils," U. S. National Museum, Bull. 92, 2 vols., 1915. For the orthoid and pentameroid brachiopods see Schuchert and Cooper, "Brachiopod genera of the suborders Orthoidea and Pentameroidea," Memoirs Peabody Museum Natural History, Vol. IV, pt. 1, 1932.

SYSTEMATIC DESCRIPTIONS

PLANTAE

THALLOPHYTA (ALGAE)

Genus GOLDSONIA Shrock and Twenhofel, n. gen.

This new genus, *Goldsonia*, is proposed for a form of alga in the Silurian argillites on Burnt Island in Goldson Arm, New World Island. The fossil consists of a fascicle of slender disconnected and jointed stems, which arise from a base and gradually increase in diameter upward. The individual stems are composed of very delicate concentric structures similar to the growth rings of modern trees. These concentric structures, of course, are not considered homologous to growth rings. The genus is referred to the calcareous red algae.

Genotype: *Goldsonia burntensis* Shrock and Twenhofel, n. sp.

GOLDSONIA BURNTENSIS Shrock and Twenhofel, n. sp.

Plate 27, figures 2–4

The specimens on which this new species is based consist of slender, tapering, stem-like structures composed of calcium carbonate or of molds left after the removal of the carbonate. The growth is radiate, with all stems arising from a central base. All stems are essentially circular in transverse section and gradually expand from diameters less than 0.1 mm where they arise at the base to about 1.8 mm at the top. Some stems attained lengths as great as 20 mm. The exteriors of the stems are sharply defined, and within the interiors are very delicate concentric structures similar to the growth rings of trees. These structures are best shown in transverse sections, but they are also visible in longitudinal sections, and some have been followed for vertical distances of several millimeters without change in diameter. As many as six of these structures are visible in some transverse sections, but not all form complete rings. In transverse section these rings suggest the invaginating tabulae of *Syringopora*, but this resemblance does not apply to the longitudinal section. The stems appear to be jointed, with the joints 2 to 3 mm apart. These joints are indicated in the molds of the stems by thin annular rings. It is not always certain that all structures referred to joints have been correctly interpreted, for some of these may represent fractures of the stem. Mushroom-like structures have been observed on the summits of three of the stems (plate 27, fig. 4), but the significance of these is not apparent.

The generic name is derived from Goldson Arm and the specific from Burnt Island where the fossil occurs in black argillite.

Occurrence.—Pike Arm formation: Black argillite on Burnt Island in Goldson Arm, New World Island. (Holotype and paratypes in Twenhofel collection.)

ANIMALIA

INVERTEBRATA

COELENTERATA

CLATHRODICTYON VESICULOSUM Nicholson and Murie

Plate 27, figure 1

This ubiquitous stromatoporoid is one of the most abundant and widely distributed fossils in the Silurian strata of northern Newfoundland. It usually occurs as concentrically laminated, flattened, discoidal or hemispherical masses which lie approximately parallel to the bedding. Individual colonies range from small irregular masses 2 cms or less in diameter to large domal structures over 15 cms in diameter and 10 cms high.

Many of the colonies are deformed and in many most or all of the internal structure has been destroyed by recrystallization, making it necessary to depend largely on shape and lamination for identification. Specimens referred to this species from the

Explanation of Plate 27

Fig. *1*—*Clathrodictyon vesiculosum* Nicholson and Murie. Transverse section of a part of a small colony, ×2, from the Goldson formation at Martin Eddy Point, Exploits River. (p. 247)

2–4—*Goldsonia burntensis* Shrock and Twenhofel, n. sp. *2*, *3*, Transverse and longitudinal sections of a paratype, ×2.5, showing size, shape, and arrangement of tubules. *4*, Polished longitudinal section, ×3.5, showing the terminal parts of several of the tubules of the holotype. The mushroom-shaped terminations are clearly shown. All specimens from the black argillite of the Pike Arm formation on Burnt Island in Goldson Arm, New World Island. (p. 247)

5, *12*—*Favosites gothlandicus* (Fought). Transverse and longitudinal sections, ×1, of a slightly distorted corallum from the outer coral zone of the Pike Arm formation on Fossil Point, Pike Arm. (p. 254)

6, *17*, *18*—*Cystiphyllum pikense* Shrock and Twenhofel, n. sp. *6*, Transverse section of the large paratype, ×0.5, from the outer coral zone of the Pike Arm formation on Fossil Point, Pike Arm. *17*, *18*, Transverse and longitudinal sections, ×1, of the holotype from same horizon and locality as *6*. Both have been retouched somewhat to show the nature of the internal structure, which is clearly visible under a microscope. (p. 251.)

7–10—*Zaphrentis stokesi* Edwards and Haime. *7*, Longitudinal section (partly restored), ×1, of a fragmental corallum showing poorly preserved tabulae in central part. *8*, Counter view, ×0.8, of a large corallum (partly restored). *9*, Transverse section, ×1, of a large corallum showing twisting of septa at the center and the cardinal fossula. *7–9*, From the outer coral zone of the Pike Arm formation on Fossil Point, Pike Arm. *10*, Transverse section, ×1, of a corallum from the coralline argillite of the Pike Arm formation on Burnt Island, Goldson Arm. (p. 250)

11, *14*, *15*—*Cyathophyllum articulatum* (Wahlenberg). *11*, Longitudinal section, ×2.5, of a corallite showing the strongly tabulated central part and the cystose peripheral zone. *14*, Transverse section, ×2.5, of a corallite showing well-developed septa and interseptal dissepiments. *15*, Same as *14*, ×1. *11*, *14*, From inner coral zone, *15* from outer coral zone, Pike Arm formation on Fossil Point, Pike Arm. (p. 250)

13—*Goldius newfoundlandensis* Shrock and Twenhofel, n. sp. Holotype, ×1.3, a fragmental pygidium from the sheared limestone in Besom Cove West, New Bay of Notre Dame Bay. (p. 264)

16—*Coenites labrosus* Hinde. Transverse section, ×2.5, of part of a colony, from the coralline argillite of the Pike Arm formation on Burnt Island, Goldson Arm, showing the size, arrangement, and lunate character of the corallite apertures. (p. 256)

Explanation of Plate 28

Figs. *1*, *2*—*Heliolites interstinctus* (Linnaeus). Transverse and longitudinal sections, ×3.5, of part of a corallum from the coralline argillite of the Pike Arm formation on Burnt Island, Goldson Arm. (p. 252)

3, *4*—*Favosites favosus* (Goldfuss). Longitudinal (×2.5) and transverse (×1) sections of part of a corallum from the outer coral zone of the Pike Arm formation on Fossil Point, Pike Arm. (p. 254)

5—*Heliolites subtubulatus* (McCoy). Transverse section, ×2.5, of a small corallum from the outer coral zone of the Pike Arm formation on Fossil Point, Pike Arm. (p. 252)

6, *7*—*Lyellia americana* Edwards and Haime. Transverse and longitudinal sections, ×3, of a fragmental corallum, from the outer coral zone of the Pike Arm formation on Fossil Point, Pike Arm, showing the large tubes and intertubular vesiculose structure. (p. 253)

8, *9*—*Lyellia superba* (Billings). Transverse and longitudinal sections, ×3, of part of a corallum from the inner coral zone of the Pike Arm formation on Fossil Point, Pike Arm, showing the very small tubes and the rather regular intertubular vesiculose structure. (p. 254)

10, *11*—*Lyellia affinis* (Billings). Transverse and longitudinal sections, ×3, of part of a corallum from the inner coral zone of the Pike Arm formation on Fossil Point, Pike Arm. (p. 253)

12, *15*—*Lyellia decipiens* Rominger. Transverse and longitudinal sections, ×3, of part of a corallum from the outer coral zone of the Pike Arm formation on Fossil Point, Pike Arm, showing the characteristic intertabular structure. (p. 253)

13, *14*—*Lyellia exigua* (Billings). Longitudinal and transverse sections, ×3, of part of a corallum from the inner coral zone of the Pike Arm formation on Fossil Point, Pike Arm. (p. 254)

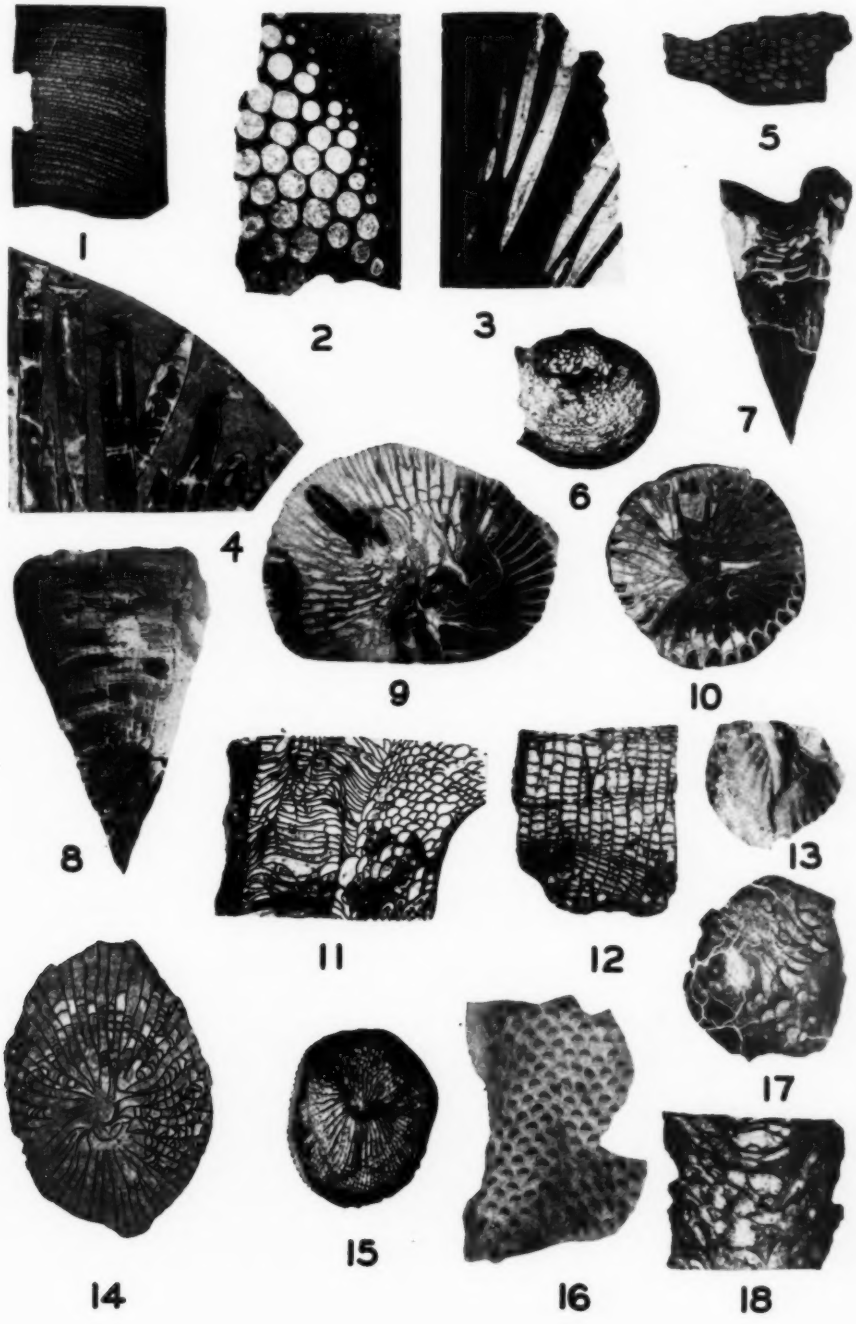
Explanation of Plate 29

Fig. *1*—*Pterinea emacerata* (Conrad). External impression of a left valve, ×1, from the black argillite of the Pike Arm formation on Burnt Island, Goldson Arm. (p. 262)

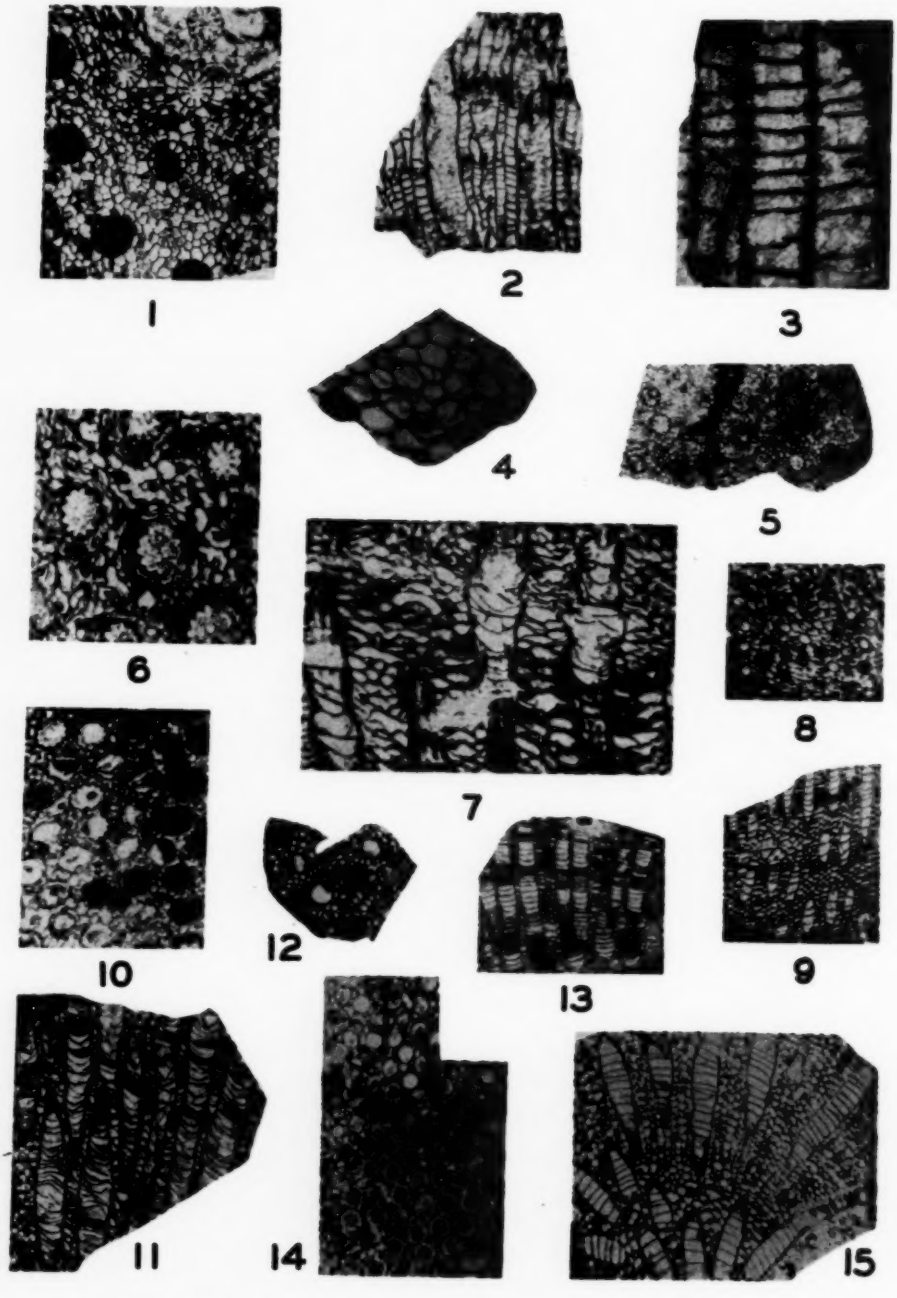
2, *3*—*Coelospira hemispherica* (Sowerby). ×1. From the fossiliferous argillite of the Pike Arm formation on Fossil Point, Pike Arm. (p. 262)

4—*Brachyprion leda* Billings. Ventral filling, ×1, with part of shell matter attached, from the fossiliferous argillite of the Pike Arm formation on Fossil Point, Pike Arm. (p. 258)

5—*Leptaena rhomboidalis* (Wilckens). Ventral valve, ×1, from the coralline argillite on Burnt Island, Goldson Arm. (p. 258)



Shrock and Twenhofel, Silurian Fossils



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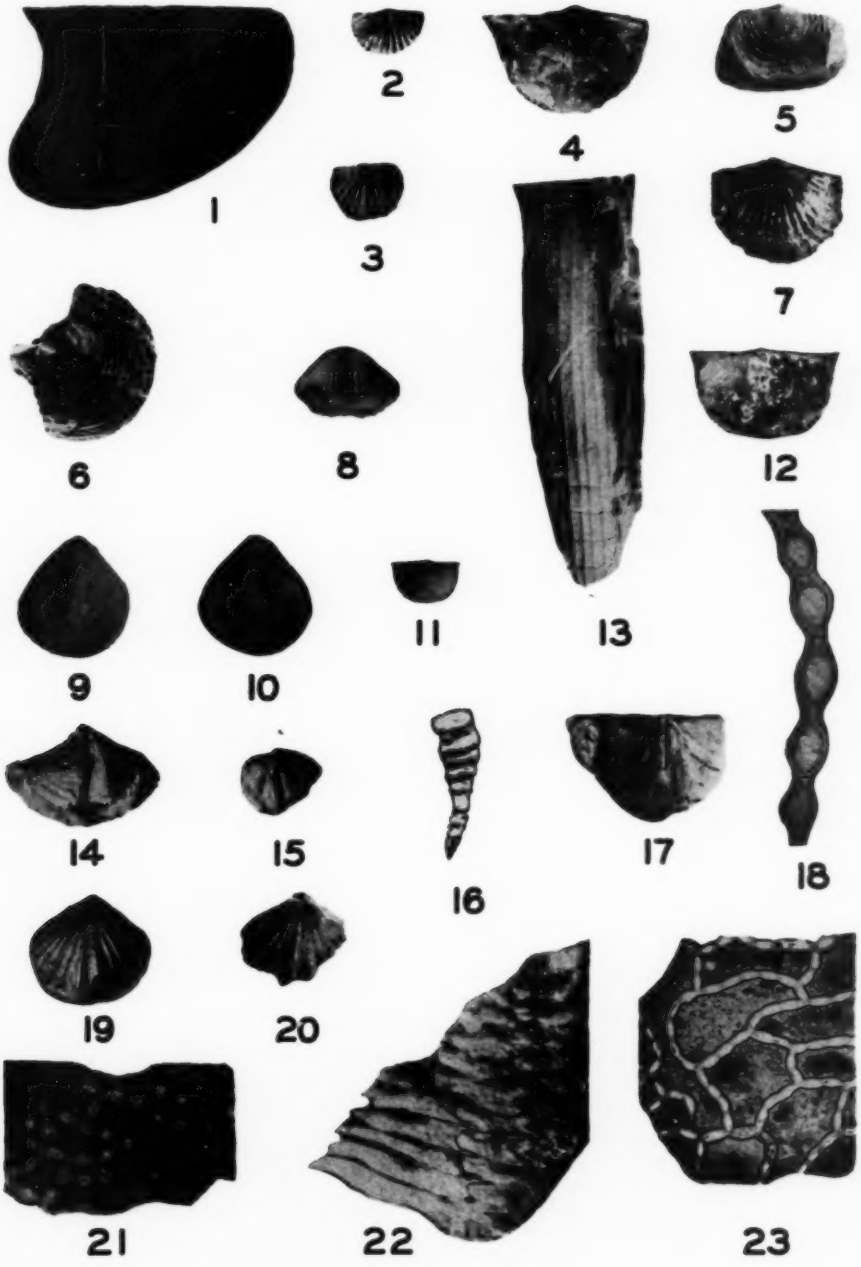
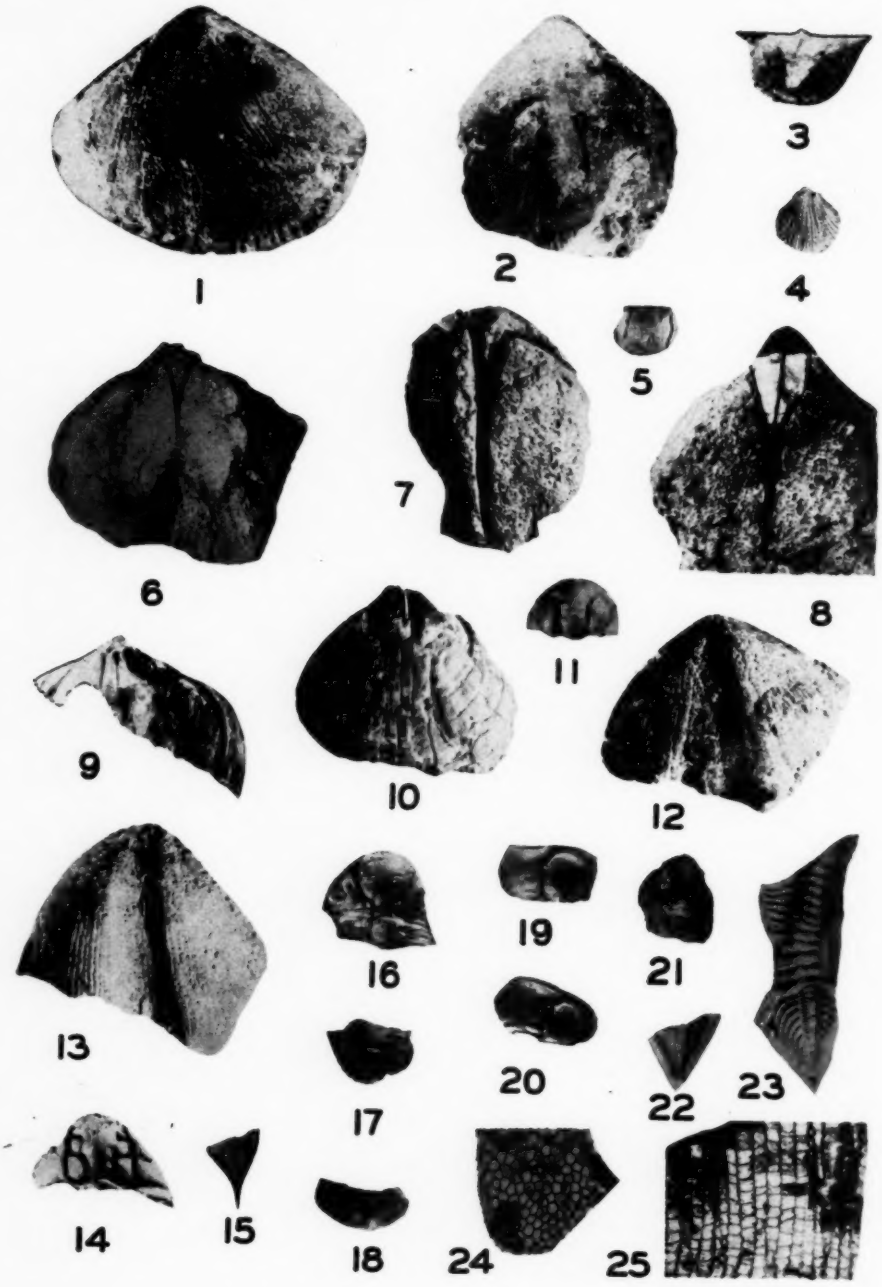


Shrock and Twenhofel, Silurian Fossils



Shrock and Twenhofel, Silurian Fossils

EXPLANATION OF PLATE 29 (*Continued*)

6—Orbiculoidea pikensis Shrock and Twenhofel, n. sp. Holotype, ×3.5, from the fossiliferous argillite of the Pike Arm formation on Fossil Point, Pike Arm. (p. 257)

7—Dolerorthis flabellites (Foerste). Ventral valve, ×1, from the outer coral zone of the Pike Arm formation on Fossil Point, Pike Arm. (p. 257)

8–10—Zygospira? exploitensis Shrock and Twenhofel, n. sp. Anterior, ventral, and dorsal views, ×2.5, of the holotype from the Goldson conglomerate at Martin Eddy Point, Exploits River. (p. 261)

11, 12—Chonetes exploitensis Shrock and Twenhofel, n. sp. Two ventral views, ×1 and ×2, of the holotype, showing the shape and the fine striations. Specimens from Goldson formation at Martin Eddy Point, Exploits River. (p. 259)

13—Kionoceras bellatulum (Billings). Fragmental shell, ×1, from the black argillite of the Pike Arm formation on Burnt Island, Goldson Arm. (p. 263)

14, 15—Eospirifer radiatus (Sowerby). Ventral and dorsal valves, ×1, from the fossiliferous argillite of the Pike Arm formation on Fossil Point, Pike Arm. (p. 262)

16—Cornulites serpularius Schlotheim. A poorly preserved shell, ×2.5, from the black argillite of the Pike Arm formation on Burnt Island, Goldson Arm. (p. 256)

17—Brachyprion robustum Twenhofel. Ventral filling, ×1, from the fossiliferous argillite of the Pike Arm formation on Fossil Point, Pike Arm. (p. 259)

18, 21, 23—Halysites catenularia (Linnaeus). *18*, Transverse section, ×3, of a few corallites showing the small quadrangular tubes between the large elliptical ones. *21*, Transverse section, ×2.5, of part of a corallum with smaller tubes. *23*, Same as *21*, ×2.5. *18, 23*, From the outer coral zone, *21* from the inner coral zone, Pike Arm formation on Fossil Point, Pike Arm. (p. 255)

19, 20—Plagiorhyncha decemplicata (Sowerby). Dorsal views, ×1.5, of two shells (*20* is slightly distorted), from the fossiliferous argillite of the Pike Arm formation on Fossil Point, Pike Arm, showing part of the plicated dorsal fold. (p. 261)

22—Armenoceras sp. Fragmental shell, ×1, from the Natlins Cove formation, Jacksons Arm, White Bay. (p. 264)

EXPLANATION OF PLATE 30

FIGS. *1, 2, 6, 12, 13—Stricklandinia exploitensis* Shrock and Twenhofel, n. sp. *1*, Dorsal exterior, ×1, of the holotype. *2*, Dorsal exterior of a paratype, ×1. *6*, Ventral valve, ×1, ground off slightly in umbonal region to show spondylium, which is retouched. *12, 13*, Ventral exteriors, ×1, showing prominent sinus. All specimens from limestone blocks in flow breccia on Upper Black Island, Notre Dame Bay. (p. 260)

3—Sowerbyella cf. *S. transversalis* (Wahlenberg). Ventral filling, ×1, of a shell from the fossiliferous argillite of the Pike Arm formation on Fossil Point, Pike Arm. (p. 258)

4—Parmorthis elegantula (Dalman). Clay squeeze of impression of ventral exterior, ×1, from the fossiliferous argillite of the Pike Arm formation on Fossil Point, Pike Arm. (p. 257)

5—Leperditia cf. *L. selwyni* Billings. Right valve, ×1, from the black argillite of the Pike Arm formation on Burnt Island, Goldson Arm. (p. 266)

7, 8—Pentamerus oblongus Sowerby. Ventral fillings, ×1, from the Goldson conglomerate along the southeast shore of Goldson Arm, New World Island, showing the nature of the spondylium. The spondylium is partly filled with fibrous calcite in *8*. (p. 259)

9, 10—Stricklandinia newfoundlandensis Shrock and Twenhofel, n. sp. *9*, Dorsal interior, ×1, showing the crura and prominent growth lines. *10*, Filling of dorsal interior, ×1, illustrated in *9*. *9* and *10* together comprise the holotype, which came from the fossiliferous argillite of the Pike Arm formation on Fossil Point, Pike Arm. (p. 260)

11—Dicranopeltis norrisensis Shrock and Twenhofel, n. sp. Holotype, ×1, an incomplete cephalon from the Goldson formation at Martin Eddy Point, Exploits River. (p. 264)

14—Calymene niagarensis Hall. Cranidium, ×1, from the black argillite of the Pike Arm formation on Burnt Island, Goldson Arm. (p. 265)

15, 21–23—Encrinurus anticostiensis Twenhofel. *15*, Fragmental pygidium, ×1, showing prominent terminal spine (which is sketched in). *21*, Cephalon and part of the thorax, ×1, of a typical specimen. *22*, Fragmental pygidium, ×1, showing some of the surface ornamentation. *23*, Fragmental specimen, ×1, showing an impression of a considerable portion of the thorax and most of the pygidium. All specimens are from the black argillite of the Pike Arm formation on Burnt Island, Pike Arm. (p. 265)

16–20—Eophacops newfoundlandensis Shrock and Twenhofel, n. sp. *16*, Top view of the cephalon and part of the thorax, ×1, of one of the paratypes. *17*, Several segments of thorax, ×1, of one of the paratypes. *18*, Pygidium, ×1, of one of the paratypes. *19, 20*, Inclined and top views, ×1, of the holotype, an incomplete cephalon, showing the shape and character of the glabella and of the right eye. All specimens from the black argillite of the Pike Arm formation on Burnt Island, Goldson Arm. (p. 265)

24, 25—Favosites hisingeri Edwards and Haime. *24*, Transverse section of part of a corallum, ×2.5, from the outer coral zone of the Pike Arm formation on Fossil Point, Pike Arm. *25*, Longitudinal section of part of a corallum, ×2.5, from the coralline argillite of the Pike Arm formation on Burnt Island, Goldson Arm. (p. 255)

limestone of Upper Black Island, the Natlins Cove formation of White Bay, and the coarse sandstones of Yellow Fox Island in Notre Dame Bay are very poorly preserved.

Occurrence.—Goldson formation: Conglomerate in Goldson Arm and at Martin Eddy Point on the Exploits River; and in blocks of conglomerate on the south shore of Northern Arm (north of Botwood). Pike Arm formation: Coral zones of Fossil Point, Pike Arm; coralline argillite on Burnt Island, Goldson Arm; and coralline sandstone on Yellow Fox Island, Notre Dame Bay. Natlins Cove formation: Lower and upper sandstone members in Sops and Jacksons Arms, White Bay (Heyl, 1937a, p. 1782). Limestone in Mouse Cove, Besom Cove and Northwest Arm, New Bay in Notre Dame Bay. (Princeton and Twenhofel collections.)

ZAPHRENTIS STOKESI Edwards and Haime
Plate 27, figures 7–10

The Newfoundland specimens referred to this species range from straight to curved, conical coralla on the external surfaces of which the septal ridges are usually clearly shown. Entire coralla seldom exceed 75 mm in length and 50 mm in greatest diameter. The septa are in two sets, of which the longer reach to or nearly to the center of the corallum and have a tendency toward twisting. The shorter septa extend only a few millimeters into the corallum and in many are obscure or apparently missing. The maximum number of septa (long and short) observed is 72. Many specimens have a well-developed cardinal fossula. If dissepiments are developed, they are confined to the outer quarter of the corallum, and they may be convex or transverse. Tabulae, which may inosculate to some extent, are well developed and bend downward where they meet the wall of the corallum. They are spaced about 10 in 10 mm, but there is some variation. The exteriors of some coralla are marked by inconspicuous annulations or rugosities.

Occurrence.—Pike Arm formation: Coral zones on Fossil Point, Pike Arm; coralline argillite on Burnt Island, Goldson Arm; coralline sandstone on Yellow Fox Island. Limestone in Northwest Arm, New Bay in Notre Dame Bay. (Princeton and Twenhofel collections.)

ENTEROLASMA CALICULUM (Hall)

This species is characterized by short, curved, rather rapidly expanding conical coralla with rugose exteriors. On many specimens the longitudinal septal furrows are prominently displayed. The septa usually number 50 or less and are in two sets. In the one set the septa reach to the center of the corallum; in the other they are short and may appear merely as spines. In many coralla the long septa fuse near the center and commonly are somewhat twisted. The calyx is deep, in some specimens comprising as much as one third the length of the complete corallum. Coralla range to as much as 2 to 3 cms in length and 1 to 1.5 cms in greatest diameter. Many of the specimens are preserved as impressions showing the nature of the exterior.

Occurrence.—Pike Arm formation: Black argillite on Burnt Island, Goldson Arm; outer coral zone on Fossil Point, Pike Arm. Limestone in Northwest Arm, New Bay in Notre Dame Bay. (Princeton and Twenhofel collections.)

CYATHOPHYLLUM ARTICULATUM (Wahlenberg)
Plate 27, figures 11, 14, 15

This coral is very abundant in the inner coral zone on Fossil Point, where locally the coralla compose large parts of the rock. The corallites generally show excellent internal structure.

A colony consists of numerous stems or corallites, which arise from others by lateral or calicinal budding. These stems begin as cones but soon change to cylindrical form. Mature stems seldom exceed 30 mm in greatest diameter. The calyx where observed is about one fourth the diameter of the stem in depth. The longer septa reach to the center of the stem where, in some instances, they are slightly twisted. The shorter septa may reach half-way to the center and occasionally fuse with the longer at their extremities. The total number of septa seldom exceeds 80 and more often averages 60. Interseptal spaces are filled with dissepiments, which are convex upward and inward toward the axis of the corallite. These are fairly uniformly spaced, and there are from 10 to 16 in an interseptal

space. The vesicles range from 0.3 mm to 2 mm in greatest dimension. The dissepiments are limited largely to the outer two-thirds of the corallite. The central zone is about one-third the diameter of a corallite and has closely spaced inosculating tabulae, of which there are about 22 in 10 mm.

Occurrence.—Pike Arm formation: Inner and outer coral zones and fossiliferous argillite on Fossil Point, Pike Arm; coralline argillite on Burnt Island, Goldson Arm; doubtful specimen from the fossiliferous sandstone of Yellow Fox Island. Limestone from Besom Cove West and reefy limestone from Northwest Arm, New Bay of Notre Dame Bay. (Princeton and Twenhofel collections.)

DIPHYPHYLLUM MULTICAULE (Hall)

This common Silurian species is represented by a small fragment, which appears to have been part of a large colony. The corallites are 3 to 4 mm in diameter and are separated by distances of 2 to 7 mm. They are slender and flexuous, and are so completely embedded in the calcareous matrix that nothing can be determined concerning the exterior surface. The septa are in two sets, the longer reaching to the center of the corallite and the shorter reaching only about one third that distance. Tabulae appear to be fairly numerous.

Occurrence.—Reefy limestone from Northwest Arm, New Bay of Notre Dame Bay. (Princeton collection.)

STROMBODES (ARACHNOPHYLLUM) DIFFLUENS (Edwards and Haime)

A single fragment of a corallum is referred to this species. This has been somewhat sheared so that dimensions are deceptive. The corallites are in close contact, and there seems to be no sharp demarkation between them. The calices are depressed below the general surface, and there is a central pit. The calices appear to be about 10 mm in diameter. The septa are in two sets, the longer of which reach the center of the corallite. They commonly unite near the central pit and two may continue as a single septum. The septa of each corallite continue as ribs on the surface beyond the calices, and these ribs unite with septa of adjacent corallites.

Occurrence.—Sheared limestone from Besom Cove, New Bay of Notre Dame Bay. (Princeton collection.)

CYSTIPHYLLUM PIKENSE Shrock and Twenhofel n. sp.

Plate 27, figures 6, 17, 18

Two specimens furnish the basis for the following description. One large specimen consists of a fragment broken transverse to the axis of the corallum and now exists as a transverse thin section 38 mm in diameter. The other specimen originally consisted of the lower 68 mm of a corallum. This smaller specimen, which is designated the holotype, begins as a cone and attains a diameter of 22–23 mm in a height of about 25 mm, thence continues with cylindrical form for 43 mm, with increase in diameter to 25 mm where it is broken. The calyx, therefore, is not preserved and the original height is not determinable. A longitudinal section shows the corallum to be composed of numerous curved plates, which are convex upward and inward toward the axis of the corallum. These range in length from less than 1 mm, in which case they are nearly always sharply curved, to large irregular plates as much as 7 to 8 mm long. The large plates are confined mainly to the central part of the corallum, where the structure is more open than on the periphery. Septa do not appear to be present, but on one part of the periphery of a transverse section of the smaller specimen small delicate plates are directed centrally from the wall of the corallum. These latter plates are 2 to 3 mm long and may represent septa.

A transverse section of the larger specimen shows small spines or carinae, about 0.5 mm long, on the convex sides of some of the curved plates to which the vesicular structure is due.

It is not certainly known that the two specimens represent the same species, but they were collected from the same horizon and locality, and for the present it is assumed that such is the case. The vesicular structure is more pronounced in the larger specimen, but this may be due to its greater size and more mature development.

This species of *Cystiphyllum* is larger than any other known Silurian form. The

internal structure is grosser than in either *C. niagarense* Hall or *C. maritimum* Billings. The internal structure does not seem to be greatly unlike *C. spinulosum* Foerste, but the corallum is larger and septal striations have not been seen on the lower, but rather on the upper, sides of the plates forming the vesicles.

Occurrence.—Pike Arm formation: Outer coral zone on Fossil Point, Pike Arm. (Twenhofel collection.)

CYSTIPHYLLUM cf. C. NIAGARENSE Hall

A poorly preserved specimen that is provisionally referred to this species was found in the limestone from Northwest Arm, New Bay of Notre Dame Bay. No accurate specific identification can be made until better preserved material is available.

Occurrence.—Limestone in Northwest Arm, New Bay of Notre Dame Bay. (Princeton collection.)

HELIOLITES INTERSTINCTUS (Linnaeus)

Plate 28, figures 1, 2

This important Silurian coral is common in the Newfoundland material. The round autopores, which average about 1.8 mm in diameter, are uniformly spaced at distances from 1.8 mm to 2.5 mm apart. There are 12 equal well-defined pseudosepta, which reach more than half way to the center of the tube. The autopores are strongly tabulate, with regularly spaced horizontal tabulae averaging 5 to 6 in 1 mm. There are also numerous dissepiments or partial tabulae, of which some are curved or domed.

The interstitial polygonal siphonopores range from 0.2 mm to as much as 0.6 mm in diameter, and are sharply set off from each other and from the autopores which they surround and separate. There are from 4 to 9 rows of these between adjacent autopores. Siphonopores are closely tabulate with 2 to 3 tabulae in one millimeter. In some cases the siphonopore walls are incomplete, so that adjacent siphonopores are connected. This may be due to fossilization.

There is a single row of slightly larger polygonal siphonopores encircling each autopore. These are generally very regular and uniform, and contrast conspicuously with the somewhat irregular arrangement of the interstitial siphonopores. The pseudosepta of the autopores in many cases are continuous with the walls of the siphonopores, and a segment of the autopore wall between adjacent pseudosepta forms a third wall.

The specimens from the Pike Arm and Goldson formations are well preserved and exhibit the characteristic features of the species. Those from the Natlins Cove formation are considerably recrystallized and show little or no internal structure. The specimens from the limestones of New Bay are also poorly preserved.

Occurrence.—Goldson formation: Limestone lenses in conglomerate at Martin Eddy Point on Exploits River. Pike Arm formation: Black and coralline argillites on Burnt Island, Goldson Arm; outer coral zone on Fossil Point, Pike Arm. Natlins Cove formation: Zone E in Sops Arm and Grandmothers Point, White Bay (Heyl, 1937a, p. 1782). Limestone from Mouse Cove and Northwest Arm, New Bay of Notre Dame Bay. (Princeton and Twenhofel collections.)

HELIOLITES SUBTUBULATUS (McCoy)

Plate 28, figure 5

This species of *Heliolites*, which is readily recognized by the small and rather distinct corallites, is common in the coralline zones of the Pike Arm formation. The autopores are circular in transverse section, average 0.75 to 1 mm in diameter, and are rather uniformly spaced at distances from 1 to 3 diameters apart. There are 12 equal and well-developed pseudosepta, which in some corallites reach almost to the center of the tube. The tabulae are principally horizontal, regularly disposed, and number 1 to 3 in 1 mm. The interstitial siphonopores are polygonal in transverse section and prismatic longitudinally. There are 3 to 5 horizontal tabulae in 1 mm. These interstitial tubes are sharply separated from adjacent tubes and from the autopores.

Occurrence.—Pike Arm formation: Outer coral zone on Fossil Point, Pike Arm; coralline argillite on Burnt Island, Goldson Arm. (Princeton and Twenhofel collections.)

Genus LYELLIA Edwards and Haime

The genus *Lyellia* is represented in the Newfoundland corals by *L. affinis*, *L. americana*, *L. decipiens*, *L. exigua* and *L. superba*. All of these exhibit the characteristics typical of the genus and differ principally in the size of the corallites. The following table indicates the characteristics of the species just mentioned:

CHARACTERISTICS OF SPECIES OF LYELLIA

	Diameter of corallites (mm)	Distance between corallites	Number and nature of septa
Lyellia affinis	1.0–1.75	Touching or up to ½ diameter apart	12. Poorly developed usually
Lyellia americana	2.5–3.0	Touching or up to 5 mm apart	12. Poorly developed
Lyellia decipiens	1.0	Greater than diameter of corallite	12. Marginal crenulations
Lyellia exigua	0.75+	Touching to diameter of 1 mm apart	Indistinct
Lyellia superba	0.5–0.6	0.5 to 1.5 mm apart	Poorly developed

LYELLIA AFFINIS (Billings)

Plate 28, figures 10, 11

This species is represented by two coralla of which one, originally about 6 cms across, is well preserved. The corallites range in diameter from 1.0 to 1.75 mm and appear circular or slightly elliptical in transverse section. They are closely packed, often touching and seldom farther apart than half a diameter. The inside walls of the corallites show some crenulations suggestive of original septal ridges. Tabulae are numerous, horizontal, convex or concave and range from 2 to 4 in 1 mm. The interstitial space is conspicuously vesiculose and is filled with unequal curved plates, which imbricate with the convex side up. The corallite walls are set off sharply from the vesiculose interstitial spaces.

Occurrence.—Pike Arm formation: Inner coral zone on Fossil Point, Pike Arm; coralline argillite on Burnt Island, Goldson Arm. Limestone in Besom Cove West and possibly in Northwest Arm, New Bay of Notre Dame Bay. (Princeton and Twenhofel collections.)

LYELLIA AMERICANA Edwards and Haime

Plate 28, figures 6, 7

This species is common in the outer coral zone on Fossil Point, Pike Arm, where it occurs as hemispheroidal coralla as much as 15 cms in diameter. Preservation is rather poor, but the large tabulated corallites and the conspicuously vesiculose interstitial spaces are readily determinable. In transverse section the curved plates of the vesiculose structure appear as boundaries of irregular cells; in longitudinal section they are convex upward and imbricate with little tendency to be disposed in longitudinal rows. There are 12 well-developed septal carinae, which in some corallites extend nearly to the center. The exterior wall of the corallite tends to have a gently scalloped appearance. This species is easily differentiated by the large corallites.

Occurrence.—Pike Arm formation: Outer coral zone on Fossil Point, Pike Arm. (Princeton and Twenhofel collections.)

LYELLIA DECIPIENS Rominger

Plate 28, figures 12, 15

This species, which closely resembles *Lyellia exigua*, from which it differs in having larger corallites, is characterized by circular corallites consistently measuring 1 mm in diameter in the mature part of the tube and separated by interstitial vesiculose structure. In transverse section the interstitial spaces appear to be filled with numerous polygonal cells, but in longitudinal section these cells become vesicles of unequal size bounded by imbricating curved plates, which are convex upward. Tabulae are well developed, horizontal, and spaced 2 to 4 in 1 mm. Septal ridges are faintly developed. The corallites are regularly spaced and usually are farther apart than one diameter.

Occurrence.—Pike Arm formation: Outer coral zone on Fossil Point, Pike Arm. (Twenhofel collection.)

LYELLIA EXIGUA (Billings)
Plate 28, figures 13, 14

The inner coral zone on Fossil Point yielded several coralla that, except for the close packing of the corallites, show the typical characteristics of this species. The circular corallites vary little from 0.75 mm in diameter and are sharply set off from the vesiculose interstitial spaces. They are closely packed and are rarely farther apart than half a diameter, though in a few instances the distances are as much as 1 mm. The tabulae of the corallites are horizontal, average 3 to 4 in 1 mm, and at some levels are crowded. The inner surfaces of the corallite walls are marked by 12 faint septal ridges. The vesicles between the corallites are unequal in size and are bounded by curved plates, which are convex upward and imbricating.

Occurrence.—Pike Arm formation: Inner coral zone on Fossil Point, Pike Arm. Limestone from Besom Cove West and possibly from Northwest Arm, New Bay of Notre Dame Bay. (Princeton and Twenhofel collections.)

LYELLIA SUPERBA (Billings)
Plate 28, figures 8, 9

The Newfoundland collections include three specimens of this delicate species of *Lyellia*. The cylindrical tabulated corallites average 0.5 to 0.6 mm in diameter and are irregularly spaced at distances ranging from 1 to 3 times the diameters of the corallites. The interstitial spaces are filled with flattened vesicles, which tend to be arranged in somewhat vertical rows. Septal ridges are poorly developed. Tabulae are usually horizontal, regularly disposed, and average 4 in 1 mm.

Occurrence.—Pike Arm formation: Inner and outer coral zones on Fossil Point, Pike Arm; coralline argillite on Burnt Island, Goldson Arm. (Twenhofel collection.)

FAVOSITES FAVOSUS (Goldfuss)
Plate 28, figures 3, 4

The Newfoundland specimens referred to this species are small hemispheroidal coralla. New corallites attain mature width in about 10 mm and average 4 to 6 mm in diameter at maturity. The corallites are fairly uniform in size and shape and range from five- to seven-sided. Tabulae are horizontal or inclined, rarely curved, show peripheral pits where they join the wall of the corallite, and are 1 to 2 per mm. Spinules are well developed along the walls of the corallites, but mural pores have not been seen.

Occurrence.—Pike Arm formation: Coralline argillite on Fossil Point, Pike Arm. (Twenhofel collection.)

FAVOSITES FORBESI Edwards and Haime

Two specimens among the corals from Notre Dame Bay are characterized by extreme variability in the size of the corallites and by conical coralla. Corallites range in diameter from less than 1 mm to more than 3.5 mm. The walls between adjacent corallites are thin, and no mural pores were observed.

Occurrence.—Pike Arm formation: Outer coral zone on Fossil Point, Pike Arm. (Twenhofel collection.)

FAVOSITES GOTHLANDICUS (Fought)
Plate 27, figures 5, 12

The Newfoundland Silurian contains many coralla of a fairly large-pored *Favosites* that agree closely with the descriptions and illustrations of *F. gothlandicus* (Fought). The corallites vary considerably in diameter, ranging from 1.5 mm to 3.5 mm, but are rather regularly polygonal in transverse section. The tabulae average about 5 in 5 mm, may be horizontal, inclined, convex, or concave, and all types may be seen in a single corallite. The mural pores may be in single or double rows.

This species differs from *F. favosus* in its smaller corallites and expanded nature of the corallum; from *F. hisingeri* in its larger and somewhat more uniform corallites; and from *F. forbesi* in its more uniform corallites. The smaller-pored specimens are very close to *F. niagarensis*.

Occurrence.—Goldson formation: Conglomerate on a small island northwest of Burnt Island, near the head of Goldson Arm, and along the southeast shore of Goldson Arm. Pike Arm formation: Inner and outer coral zones on Fossil Point, Pike Arm; coralline argillite on Burnt Island, Goldson Arm; sheared pebbly sandstone on Yellow Fox Island. Natlins Cove formation: Zones

A, E and F, Sops Arm, White Bay (Heyl, 1937a, p. 1782). Limestone from Northwest Arm, New Bay of Notre Dame Bay. (Princeton and Twenhofel collections.)

FAVOSITES HISINGERI Edwards and Haime

Plate 30, figures 24, 25

This species of *Favosites* is widely distributed in the Silurian rocks of northern Newfoundland. Many specimens, however, from White Bay and Yellow Fox Island have been so sheared and altered that identification is uncertain.

Corallites range in diameter in the same corallum from less than 0.5 mm to more than 1.5 mm, are asymmetrically polygonal in outline, and have well-developed, unequally spaced tabulae, which average 2 in 1 mm. The tabulae are usually horizontal, rarely inclined, and almost never curved. Mural pores, arranged in regular or irregular manner between adjacent tabulae, average 4 in each intertabular space, though the number varies, and they may be in two rows or scattered. Well-preserved coralla have septal spines, of which some may reach almost to the center of the corallite.

Occurrence.—Goldson formation: Conglomerate at Martin Eddy Point on Exploits River; blocks of conglomerate near Wigwam Point at the mouth of Exploits River; conglomerate on a small island northwest of Burnt Island, Goldson Arm; calcareous lenses in conglomerate on the southeast shore of Goldson Arm. Pike Arm formation: Inner and outer coral zones on Fossil Point, Pike Arm; coralline argillite on Burnt Island, Goldson Arm; sheared pebbly sandstone on Yellow Fox Island. Natlins Cove formation: Zone E, Sops Arm, White Bay (Heyl, 1937a, p. 1782). Limestone in Besom Cove West and Northwest Arm, New Bay of Notre Dame Bay. (Princeton and Twenhofel collections.)

HALYSITES CATENULARIA (Linnaeus)

Plate 29, figures 18, 21, 23

The coralla of this common species vary greatly in architecture, from very loose to very closely woven structures in which 4 or 5 corallites radiate from a common point like petals of a tiny flower. The corallites range in length from 1 to 3 mm, with from 3 to 8 corallites in a distance of 10 mm, and in width from 0.5 to 1 mm. In most specimens there are tiny tubules between the main corallites. These may be circular or quadrangular in transverse section. They range in length from 0.5 to 1 mm and in width from 0.3 mm to 0.75 mm. Both corallites and tubules are closely tabulate, with the tabulae in the former horizontal and spaced about 8 in 5 mm; in the latter, convex upward and spaced about 13 in 5 mm. Most of the coralla are less than 10 cms across, but one large specimen measures over 18 cms in greatest diameter. Preservation is not always good enough to show the internal structure.

Occurrence.—Pike Arm formation: Inner and outer coral zones on Fossil Point, Pike Arm; coralline and black argillites on Burnt Island, Goldson Arm. Natlins Cove formation: Zone E, Sops Arm, White Bay. Limestones in Besom Cove West and Northwest Arm, New Bay of Notre Dame Bay. (Princeton and Twenhofel collections.)

HALYSITES CATENULARIA MICROPORUS (Whitfield)

This species differs from the common *H. catenularia* only in having much smaller corallites, which average about 0.5 mm in diameter. Several specimens with such corallites are present among the corals from Notre Dame Bay.

Occurrence.—Pike Arm formation: Outer coral zone on Fossil Point, Pike Arm. (Twenhofel collection.)

CLADOPORA NEWFOUNDLANDENSIS Shrock and Twenhofel, n. sp.

Included in the fossils from White Bay are several blocks of recrystallized limestone, of which the surfaces are covered by a tangled mat of coralline stems, which appear to have the general structure of *Cladopora*. The stems differ, however, from all known Silurian species of that genus in greater size and grosser structure. All specimens are composed of saccharoidal, recrystallized calcite.

The coralla form cylindrical bifurcating stems that average 10 to 20 mm in diameter and attain diameters as great as 30 mm, the diameters being greatest just before bifur-

cation. The corallites, which average 1 to 1.25 mm in diameter and enlarge to as much as 2 mm at the surface, show neither septa nor tabulae, though these may be lacking because of the poor preservation. The corallite walls are thin, and no mural pores have been observed. All stems are more or less flattened, and recrystallization has destroyed the original surface and most of the internal structure. The specimens are not illustrated because of extremely poor preservation.

Occurrence.—Natlins Cove formation: Zone E, Sops Arm, White Bay (Heyl, 1937a, p. 1782). (Syntypes in Princeton collection.)

Coenites labrosus Hinde

Plate 27, figure 16

The Newfoundland specimens referred to this species are incrusting coralla in the form of thin sheets 1 mm or less thick. The calices of the corallites appear in transverse section as lunate or crescentic openings 0.65 to 0.85 mm wide along the greatest diameter and about one third that distance across between the convex and concave walls. On the surface the convex wall of the calyx is extended to produce a crescentic lip, but no broad toothlike projection from the inside of the concave wall has been observed as is the case in *C. lunatus*. Along the line approximately at right angles to the greatest diameters of the calices the latter are disposed at distances from 0.6 to 1 mm apart and are uniformly convex in one direction and concave in the other. There is no tendency for the calices to be arranged in twisted lines about a point as in some species. Laterally the calices are almost in contact over much of the surface and are rarely more than 0.5 mm apart.

Vertical sections show that corallites lie prostrate for about five sixths of the length (2.5 to 3 mm), then bend abruptly upward to emerge nearly at right angles to the surface. The interstitial space between adjacent corallites is filled with long flattened vesicles, which are formed by gently convex imbricating plates. There are a few poorly preserved transverse tabulae, which are distantly spaced. No mural pores are apparent. The method of attachment is not clear, but the under surface has not been seen fastened to a shell.

The Newfoundland specimens resemble *C. lunatus*, from which they differ in having somewhat larger corallites, in lacking the rounded toothlike projection from the inside wall, and in not showing a thickening of the corallite wall near the surface. Reference to *C. labrosus* seems best at present, although the three teeth characteristic of the English forms of that species have not been seen. This lack may not be as significant as might at first appear, for the teeth are not always observable on the English forms.

Occurrence.—Pike Arm formation: Black and coralline argillites on Burnt Island, Goldson Arm. (Princeton and Twenhofel collections.)

Echinoderma

Echinoderm columnals, probably in most cases crinoidal, are common in all of the Silurian formations of northern Newfoundland, but no calices have yet been discovered. The columnals, which are often conspicuous because of the coarsely crystalline nature, range in diameter from less than 1 mm to more than 12 mm and are commonly sculptured with fine grooves, which radiate from the central perforation. Stems as long as 60 mm were found. The columnals range in thickness from less than 1 mm to over 2 mm. One specimen from Sops Arm (no. 367) shows a stem with several "brace" roots.

Occurrence.—Botwood, Goldson and Pike Arm formations in Notre Dame Bay; limestone of Upper Black Island, Notre Dame Bay; Natlins Cove formation of White Bay. (Princeton and Twenhofel collections.)

Annelida

Cornulites serpularius Schlotheim

Plate 29, figure 16

The single specimen collected is 8.5 mm long with part of the apical end missing, but an impression shows this to have been about 3 mm long. The shell is slightly curved, has a width of about 3 mm at the larger, apertural end, and the diameter increases uniformly toward the apex. Eight annulations are preserved. Some of these are more abrupt on the apertural side, others on the apical side. The surface of the shell is ornamented with very faint longitudinal striae. The indistinctness of

these striae and the differences in the slopes of the annulations may be due to fossilization.

Occurrence.—Pike Arm formation: Black argillite on Fossil Point, Pike Arm. (Twenhofel collection.)

BRYOZOA

HALLOPORA ELEGANTULA Hall

This species is sparingly represented in the Newfoundland Silurian in limestone lenses lying in the Goldson conglomerate. No free zoaria were collected.

The zoarium is ramose, with the branching stems 3 to 5 mm in diameter. The surfaces of the stems are not exposed. The zooecia are cylindrical, thin-walled, about 5 in 2 mm, and separated from each other by one or more angular mesopores. No zooecial opercula were observed. The immature region is long, shows few diaphragms, rises with small angular divergence from the axial region of the stems, and extends vertically for a distance of 1.5 to 2 mm before sharply turning toward the periphery, which it reaches in 0.5 to 0.75 mm, with the zooecia directed upward.

Occurrence.—Goldson formation: Limestone lenses in blocks of conglomerate on Wigwam Point at the mouth of Exploits River. (Twenhofel collection.)

BRACHIOPODA

ORBICULOIDEA PIKENSIS Shrock and Twenhofel, n. sp.

Plate 29, figure 6

The following description is based on a single valve, which appears to be the ventral since it shows the closed pedicle opening. The shell is small, about 8 mm wide along the line perpendicular to the greatest diameter of the pedicle opening, and approximately 3.5 mm from the posterior end of the pedicle opening to the anterior border. The distance to the opposite border is not determinable. The convexity of the valve is apparently moderate, the apex rising about 1 mm above the plane of the base. The apex of the valve apparently is eccentric and nearer the posterior side. There are at least 19 concentric ridges, which are impressed into the argillaceous matrix. The corneous material of the shell appears to have been thin, judging from the film which in part remains.

Occurrence.—Pike Arm formation: Fossiliferous argillite on Fossil Point, Pike Arm. (Holotype in Twenhofel collection.)

DOLERORTHIS FLABELLITES (Foerste)

Plate 29, figure 7

Dolerorthis flabellites SCHUCHERT and COOPER, *1932*, Peabody Mus. Nat. Hist. Mem. 4, pt. 1, p. 88, pl. 5, figs. 17, 22, 24.

The Newfoundland representatives of this species are almost identical in appearance to those from Anticosti. On the best preserved of the shells the width along the hinge line is about 200 mm; along the line of greatest width, which is about mid-length, 24 mm. The length is about 15 mm. This particular shell, which is a dorsal valve, has 24 prominent rounded plications, of which all extend to the beak.

Occurrence.—Pike Arm formation: Outer coral zone on Fossil Point, Pike Arm; coralline argillite on Burnt Island, Goldson Arm. (Princeton and Twenhofel collections.)

PARMORTHIS ELEGANTULA (Dalman)

Plate 30, figure 4

Parmorthis elegantula SCHUCHERT and COOPER, *1932*, Peabody Mus. Nat. Hist. Mem. 4, pt. 1, p. 128, pl. 21, figs. 2, 3, 9, 10, 13, 14, 16, 29.

The Newfoundland representatives of this common Silurian species are poorly preserved and frequently distorted, hence many are difficult to identify with complete satisfaction. A specimen from the conglomerate at Martin Eddy Point shows an impression of a dorsal interior, and distorted specimens are fairly common in the argillaceous phases of the Pike Arm formation. The best-preserved shell is about 12 mm wide at mid-length and 8 to 9 mm along the hinge line. This same shell is 10 mm long from beak to anterior border. There are 3 to 4 striations to 1 mm on the anterior margin.

Occurrence.—Goldson formation: Conglomerate at Martin Eddy Point on Exploits River. Pike Arm formation: Fossiliferous argillite on Fossil Point, Pike Arm; black argillite on Burnt Island, Goldson Arm. (Princeton and Twenhofel collections.)

MENDACELLA UBERIS (Billings)

A single dorsal valve is referred to this species. The shell is subequally biconvex. There is a shallow central depression on the umbonal part of the dorsal valve, but this feature dies out anteriorly. The surface is ornamented by fine radial striations, which originate near or at the beak and are spaced about 3 to 1 mm. The valve, which appears to be that of a young individual, is about 6.5 mm wide at about mid-length and 6 mm along the hinge line. It is about 5 mm long.

Occurrence.—Goldson formation: Limestone lens in the conglomerate at Martin Eddy Point on the northwest shore of Exploits River. (Twenhofel collection.)

SOWERBYELLA cf. S. TRANSVERSALIS (Wahlenberg)

Plate 30, figure 3

The single specimen of this species is an impression of a ventral valve. This indicates that the shell is punctate. The shape is that of *S. transversalis*. The width along the hinge line is about 9 mm, and the length from beak to anterior border, 5.5 to 6 mm. The convexity is moderate and, like that of *S. transversalis*, greatest near the hinge line. The place and nature of the median septum and the diductor muscle scars are clearly shown. The teeth are indistinct. No surface ornamentation is apparent. The reference to *S. transversalis* is tentative.

Occurrence.—Pike Arm formation: Fossiliferous argillite on Fossil Point, Pike Arm. (Twenhofel collection.)

LEPTAENA RHOMBOIDALIS (Wilckens)

Plate 29, figure 5

This wide-ranging species is sparingly represented in two horizons in the Pike Arm formation. The specimens are poorly preserved and somewhat deformed. The prominent anterior geniculation and the very wrinkled ornamentation over the visceral part of the exterior are well shown. The largest specimen collected measures 26 mm along the hinge line, 30 mm wide about half-way between the hinge line and geniculation, and 12.5 mm from beak to geniculation. The part of the valve below the geniculation, which is at right angles, measures at least 5 mm.

Occurrence.—Pike Arm formation: Outer coral zone on Fossil Point, Pike Arm; black and coralline argillites on Burnt Island, Goldson Arm. (Princeton and Twenhofel collections.)

BRACHYPRION ELEGANTULUM Twenhofel

Brachyprion elegantulum TWENHOFEL, *1927*, Geology of Anticosti Island: Canada Geol. Survey, Mem. 154, p. 189, pl. 16, fig. 18.

The single shell referred to this species is about 10 mm wide on the hinge line, where it has its greatest width, and about 4.5 mm long from beak to anterior border. The extremities of the hinge line are slightly alate and are prolonged about 1 mm beyond the body of the shell. There is obscurely preserved denticulation along the hinge line for about one third the distance from the beak toward the lateral extremities. The shell is uniformly convex and has its surface marked by at least 24 radiating striae, which rise near the beak or anterior to the beak. The later striations seem to arise by implantation.

Occurrence.—Pike Arm formation: Fossiliferous argillite on Fossil Point, Pike Arm. (Twenhofel collection.)

BRACHYPRION LEDA Billings

Plate 29, figure 4

Brachyprion leda TWENHOFEL, *1927*, Geology of Anticosti Island, Canada Geol. Survey, Mem. 154, p. 188, pl. 22, figs. 10, 11.

The shells are 21 to 24 mm wide along the hinge line, the line of greatest width, and 12 to 14.5 mm long from beak to anterior border. The lateral extremities of the hinge line are prolonged 2 mm beyond the body of the shell, thereby producing an alate appearance. Faint denticulation extends laterally from the beak for about one-fourth the distance to the ends of the hinge line. The surface of the ventral valve is gently and uniformly convex from the beak anteriorly for about five-sixths the length, and then becomes somewhat more sharply convex for the remainder of the distance. The surface is ornamented by numerous radial striae, which are spaced about 4 to 1 mm.

The Newfoundland shells are essentially identical with *B. leda* from the Gun River and Jupiter formations of Anticosti.

Occurrence.—Pike Arm formation: Fossiliferous argillite on Fossil Point, Pike Arm. (Twenhofel collection.)

BRACHYPRION ROBUSTUM Twenhofel
Plate 29, figure 17

Brachyprion robustum TWENHOFEL, *1927*, Geology of Anticosti Island: Canada Geol. Survey, Mem. 154, p. 190, pl. 16, figs. 12–15.

The average shell, which has a subcircular outline with truncation on the hinge line, is about 24 mm wide along the slightly alate hinge line and about 20 mm long from beak to anterior border. The hinge line is denticulated for about one-third the distance from the beak to the lateral extremities. The surface of the shell is gently and uniformly convex from beak to anterior border, though the degree of convexity in the preserved specimens is probably not the same as in the original shells, since the latter have been deformed and somewhat flattened. The surface of the shell is covered by radial striae spaced about 5 in 1 mm. Every fifth striation is somewhat more prominent than the intervening four. The striations seem to arise by implantation

Occurrence.—Pike Arm formation: Fossiliferous argillite on Fossil Point, Pike Arm; coralline argillite on Burnt Island, Goldson Arm. (Princeton and Twenhofel collections.)

SCHUCHERTELLA ALTERNIRADIATA (Shaler)

This species is represented by a single impression of an exterior of the ventral valve. It is incomplete and slightly deformed, but has normal dimensions. The length from beak to anterior border is about 20 mm. The surface has the typical ornamentation of closely spaced angular radial striations, which increase by implantation. The specimen is not sufficiently well preserved to show the concentric striations, which are responsible for the annulated aspect shown by the radial striations. The striations have a somewhat bundled appearance. There are about 10 of them in 5 mm at mid-length and 6 in 5 mm at the anterior margin.

Occurrence.—Goldson formation: Conglomerate on the southeast shore of Goldson Arm. (Twenhofel collection.)

CHONETES EXPLOITENSIS Shrock and Twenhofel, n. sp.
Plate 29, figures 11, 12

The shell has a somewhat semicircular outline, is widest along the hinge line, where the largest specimen measures 9.5 mm, and is about 5 mm long from beak to anterior border. The hinge line is slightly acuminate at the extremities, and from it on each side of the beak rise three spines, which are bent outward from the beak, and each is about 1 mm long. These have been seen on only one specimen, a syntype, which shows the outer two on one side and the inner one on the other. The ventral valve is strongly convex, and the dorsal has not been seen. The surface is ornamented with very fine striae 6 to 9 in 1 mm near the anterior border, and these are of equal height and width. New striae arise by implantation. The interior is unknown.

The shell of *C. exploitensis* is far more finely striate and considerably smaller than the common European *C. plicatellus*, but it has about the same convexity. *C. cornutus* from the Clinton of New York is of approximately the same size and shape, but is less convex and less finely striate. *C. exploitensis* is also more finely striate than *C. tenuistriatus* from the Ross Brook formation of the Arisaig section of Nova Scotia. It differs from *C. primigenius* of the Anticostian Silurian in being more convex and more finely striate. These differences are considered adequate for separating the Newfoundland specimens as a new species.

Occurrence.—Goldson formation: Limestone layers in conglomerate at Martin Eddy Point, Exploits River. (The holotype, a syntype, and other specimens are in the Princeton collection; a specimen is in the Twenhofel collection.)

PENTAMERUS OBLONGUS Sowerby
Plate 30, figures 7, 8

The dozen Newfoundland specimens referred to this species are chiefly internal fillings of the beak portion of ventral valves. Some of the fillings are surrounded by na-

tural casts of the original shell, but these casts of fibrous calcite seem to be much thicker than was the original shell. The largest specimen collected is 36 mm wide at mid-length. Its length is about 40 mm, and the spondylium, over 8 mm wide at the posterior end, extends at least 28 mm anteriorly. Several smaller specimens show the same proportional dimensions. There do not seem to be any dorsal valves in the material collected.

Occurrence.—Goldson formation: Conglomerate along the southeast shore of Goldson Arm; conglomerate at Martin Eddy Point, Exploits River. (Princeton and Twenhofel collections.)

STRICKLANDINIA EXPLOITENSIS Shrock and Twenhofel, n. sp.

Plate 30, figures 1, 2, 6, 12, 13

Shells of this species are biconvex, with curvature across the dorsal valve strongly and uniformly convex and across the ventral valve less convex, with a shallow sinus arising at the beak and extending to the anterior border of the shell, where it measures about 4 mm in width. The greatest width is about mid-length of the shell, where it may be as much as 50 mm. The length, following the curvature of the shell, is about 40 mm from beak to anterior border. The curvature of the dorsal valve is very convex from the dorsal beak anteriorly for about half the distance to the anterior border, after which it becomes less curved. The surfaces of both valves are ornamented with numerous rounded plications, spaced 5 to 6 in 5 mm. These rise at the beak or anteriorly by bifurcation. In some shells the striations appear to exist as pairs, which are separated by deeper grooves than those separating the two striations of a pair. This character has not been described on any other species of *Stricklandinia*, and in this respect *S. exploitensis* differs from all known species. The spondylium is narrow, apparently not over 0.25 to 0.5 mm wide, and extends almost to mid-length from the beak.

This species bears some resemblance to two Anticosti species. It has about the same outline as *S. salteri* and *S. brevis*. It differs from the former, however, in the presence of striations and the shallow ventral sinus; and from the latter in lacking the dorsal fold and in the character of the radial ornamentation.

Occurrence.—Limestone blocks in the flow breccia on Upper Black Island, Notre Dame Bay. Pike Arm formation: Two fragments were collected from the coralline argillite on Burnt Island, of which one seems to be slightly more coarsely plicated than those from Upper Black Island. (Holotype and paratypes in the Princeton collection, other specimens in Twenhofel collection.)

STRICKLANDINIA NEWFOUNDLANDENSIS Shrock and Twenhofel, n. sp.

Plate 30, figures 9, 10

This species is based on two specimens. One is a filling of a ventral valve, showing a small part of the spondylium. The other is a filling showing the interior surface of a dorsal valve, the cruralium, and the external impression of the dorsal surface of the shell. The ventral filling indicates a width along the hinge line of at least 50 mm, and the width anteriorly may have been more. The other specimen shows a width at about mid-length of at least 32 mm and a length from beak to anterior border of at least 28 mm. This latter specimen is considered the holotype.

The impression of the dorsal interior shows several concentric growth lines. The impressions of the crural plates expand from less than 1 mm apart to almost 4 mm at a distance of 18 mm anteriorly. They appear to end beyond mid-length of the shell. Besides the impressions of the crural plates, the space between them is bisected by a somewhat fainter impression, which may mark a ridge on the interior of the shell. The shells are not sufficiently well preserved to show much of the external ornamentation other than concentric growth lines. Plications have not been seen, and it is doubtful if such are present.

Occurrence.—Pike Arm formation: Fossiliferous argillite on Fossil Point, Pike Arm. (Holotype and other specimen in Twenhofel collection.)

RHYNCHOTRETA CUNEATA AMERICANA (Hall)

Three young and fragmental shells are referred to this species. The best-preserved

specimen shows the posterior part of a ventral valve, on which are preserved 10 angular plications which reach to the beak.

Occurrence.—Goldson formation: Conglomerate at Martin Eddy Point, Exploits River. Pike Arm formation: Black argillite on Burnt Island, Goldson Arm. (Princeton and Twenhofel collections.)

PLAGIORHYNCHA DECEMPLICATA (Sowerby)

Plate 29, figures 19, 20

Plagiorhyncha decemplicata TWENHOFEL, *1927*, Geology of Anticosti Island: Canada Geol. Survey, Mem. 154, p. 212.

The half dozen shells referred to this species are characterized by two strongly developed, centrally located plications on the dorsal valve. These plications make their appearance in a sinus on the umbo of the valve and rise anteriorly to form a narrow fold. On the ventral valve the umbonal part of the shell has three plications, of which the middle one becomes depressed anteriorly so as to occupy the middle of a sinus bordered on each side by the other two plications. Marginal to the central plications of the dorsal valve are four additional plications on each side and one or two other less prominent ones along the lateral borders. The greatest width is just anterior to the hinge line where the best-preserved shell measures 12 mm. The same shell has a length of about 10 mm.

Occurrence.—Pike Arm formation: Fossiliferous argillite on Fossil Point, Pike Arm. (Princeton and Twenhofel collections.)

ZYGOSPIRA? EXPLOITENSIS Shrock and Twenhofel, n. sp.

Plate 29, figures 8–10

This species is represented by a single well-preserved shell, which has the general appearance of *Zygospira*, except that it is a little more narrow than the shells of most species of that genus and has somewhat the shape of *Homeospira*, to which it was first referred, except that it is much more finely striate. The shell is about 8 mm long, 7 mm wide and 5 mm thick. The ventral valve is quite convex and rather uniformly curved from beak to anterior border. This valve has a well-marked sinus, which starts at the beak and has a width of 2 mm at the anterior border. The beak is curved over that of the dorsal valve. The dorsal valve is gently convex, with a shallow sinus extending from beak to anterior border. The surfaces of both valves are ornamented with fine radial striae, of which all extend to the beaks. There are 14 striae on each lateral slope and 5 in the sinus on each valve. The interior is unknown, hence reference to *Zygospira* is provisional.

Occurrence.—Goldson formation: Conglomerate at Martin Eddy Point, Exploits River. (Holotype in Twenhofel collection.)

ATRYPA RETICULARIS (Linnaeus)

This common brachiopod is sparingly represented in the Silurian strata of Notre Dame Bay. The material collected includes two small nearly complete shells with the following dimensions: length, 10–11 mm; width, 12 mm; thickness, 5–8 mm. The smaller specimen is somewhat distorted. Both exhibit the surface features characteristic of the species as it is developed in Anticosti and in the United States.

Occurrence.—Goldson formation: Limestone lenses in conglomerate at Martin Eddy Point, Exploits River; conglomerate along the southeast shore of Goldson Arm. Pike Arm formation: Outer coral zone on Fossil Point, Pike Arm; black argillite on Burnt Island, Goldson Arm. (Twenhofel collection.)

LISSATRYPA ATHEROIDEA Twenhofel

Lissatrypa atheroidea TWENHOFEL, *1927*, Geology of Anticosti Island: Canada Geol. Survey Mem. 154, p. 218.

Shells of this species are small and of subovate or subcircular outline. Externally they closely resemble *Whitfieldella*, but internally they are different in that the spiralia have the apices directed toward the central part of the dorsal valve. The shell matter exfoliates readily, and the surface is marked by numerous concentric growth striations. The Newfoundland shell, which is a dorsal exterior, is 11 mm wide at midlength, the line of greatest width, and 9 mm long from beak to anterior border. It is identified with *L. atheroidea* on external resemblance alone. Until the interior is known the identification can not be considered defi-

nite, and it is possible that the shell may actually represent a species of *Whitfieldella*.

Occurrence.—Goldson formation: Conglomerate at Martin Eddy Point, Exploits River. (Twenhofel collection.)

EOSPIRIFER RADIATUS (Sowerby)

Plate 29, figures 14, 15

The largest shells range from 20 to 25 mm wide along the hinge line, which is the line of greatest width, and are about 12 mm long from beak to anterior border. The prominent sinus on the ventral valve is about 5 mm wide at the anterior border and 1 to 1.5 mm deep at that position. Posteriorly it narrows and becomes more shallow but extends entirely to the beak. The sides are abrupt and steep. The dorsal fold exhibits the same relative proportions. Closely spaced striae, about 5 to 1 mm, ornament the entire surface of the shell. These striations develop by bifurcation. So far as observed there are no radial ridges as are sometimes seen on individuals of this species. The Newfoundland specimens closely resemble those from Anticosti.

Occurrence.—Pike Arm formation: Very common in the fossiliferous argillite on Fossil Point, Pike Arm; a single specimen from the coralline argillite on Burnt Island, Goldson Arm. (Princeton and Twenhofel collections.)

COELOSPIRA HEMISPHERICA (Sowerby)

Plate 29, figures 2, 3

This widely ranging species is present in comparative abundance in the Newfoundland section. The maximum dimensions of the shells are about 6 mm from beak to anterior border and 11 mm wide along the line of greatest width about half way between the hinge line and anterior border. The rounded plications are crossed by concentric growth striae. The prominent middle plication of the ventral valve divides about midway between the hinge line and anterior border and is flanked on each side by 4 or 5 distinct plications, and 1 or 2 more or less obscure ridges. The Newfoundland specimens are somewhat smaller than those from Anticosti, but in other respects are quite similar.

Occurrence.—Goldson formation: Doubtfully present in calcareous layers in the conglomerate at Martin Eddy Point, Exploits River. Pike Arm formation: Abundant in fossiliferous argillites on Fossil Point, Pike Arm; black and coralline argillites on Burnt Island, Goldson Arm. (Princeton and Twenhofel collections.)

MOLLUSCA

PELECYPODA

A number of poorly preserved pelecypods are included in the fossils from northern Newfoundland, but of these only one group of specimens is considered worthy of description. The other specimens are either incomplete or so poorly preserved that little can be determined concerning original characteristics.

PTERINEA EMACERATA (Conrad)

Plate 29, figure 1

This species is represented by five specimens, of which three show the radial striations. A left valve is 40 mm along the hinge line but this is not the maximum dimension, as the top of the posterior wing is broken away. The best preserved specimen is little deformed and shows rather low convexity except near the hinge line, where the umbo is quite convex. The length from the beak to the posterior ventral margin is about 44 mm. This dimension parallels the radii. The surface is ornamented with numerous closely spaced concentric and radial striations. The specimens seem to be identical with the well-known and widely distributed *P. emacerata* from the Clinton of the United States and Canada.

Occurrence.—Pike Arm formation: Black argillite on Burnt Island, Goldson Arm. (Twenhofel collection.)

GASTROPODA

The Newfoundland Silurian fauna includes a considerable number of gastropods, which occur as internal fillings and external impressions, and of these only generic determinations seem possible. In general the shells are confined to the argillaceous strata of the Pike Arm formation.

Two large fillings of a gyronemoid or pleurotomarid shell were collected: one, from the fossiliferous argillite of the Pike Arm formation on Burnt Island; the other,

from a limestone lens in the Goldson conglomerate at Martin Eddy Point on the Exploits River. These shells have 3 to 4 complete whorls, an apical angle of about 60°, and a height of about 35 mm. There is one prominent angular ridge in about the middle of the whorl, but the mold of the exterior shows no indication of a slit-band. The shells, on this account, are referred provisionally to the genus *Gyronema*.

Six small distorted planospirally coiled shells are referred to the genus *Sinuites* on the basis of the nature of coiling, presence of small umbilicus, spiral ornamentation in the form of numerous striations, and absence of a slit-band. Nothing is known about the aperture. The specimens came from the fossiliferous argillite of the Pike Arm formation on Fossil Point, Pike Arm.

Several small planospirally coiled internal fillings, of which one shows faint revolving striations, were collected from the black argillite of the Pike Arm formation on Burnt Island, Goldson Arm. The shells are closely coiled, and if the original shell material were present it is likely that the inner whorl would not show. The dorsal surfaces of the fillings show a narrow (1 mm wide) shallow groove, which evidently corresponds to the slit-band. These shells are referred to the genus *Bellerophon*.

A single and partial filling of a large shell from the fossiliferous argillite of the Pike Arm formation on Fossil Point, Pike Arm, shows the apertural portion of what appears to be a deformed specimen of *Salpingostoma*.

Several fillings of high-spired shells closely resemble *Hormotoma*. These shells range in height from 5 to 15 mm and are in all cases less than 5 mm in diameter at the apertural end. The number of whorls ranges from 7 to 12, and the apical angle is 10° to 12°. The shells occur in the fossiliferous black argillite of the Pike Arm formation on Burnt Island, Goldson Arm, and in limestone lenses in the Goldson conglomerate at Martin Eddy Point on Exploits River.

Fillings somewhat smaller than those referred to *Gyronema*, but different also in containing fewer whorls, a much lower spire and a larger apical angle (about 95°), probably represent another species of *Gyronema*. Neither the aperture nor any external markings are preserved. The specimens came from the fossiliferous argillite of the Pike Arm formation on Fossil Point, Pike Arm.

Specimens from the black argillite of Burnt Island show spiral striations on the surface and a prominent median groove suggesting a slit-band. In these there are three whorls to the complete shell, and the apical angle is slightly less than 90°. These specimens are referred provisionally to the genus *Lophospira*.

Cephalopoda

Fragmental cephalopods were collected from the Pike Arm formation on Fossil Point, Pike Arm, and on Burnt Island, Goldson Arm, and from the Natlins Cove formation in White Bay, but of these only two specimens merit description.

Kionoceras bellatulum (Billings)

Plate 29, figure 13

The fragmental shell referred to this species consists of most of the living chamber, which is somewhat over 47 mm long, and four camerae which occupy a length of 16 mm. The transverse sutures are about 4 mm apart. The diameter of the shell at the aperture must have been about 24 mm, and the living chamber tapers very slightly. The shell is somewhat deformed, and not enough is preserved to determine the apical angle, but it seems to be about the same as that of *K. bellatulum*. The surface is ornamented by prominent angular or slightly rounded longitudinal ridges, separated by longitudinal flutings about 1 mm wide. Each fluting is divided into halves by a marked striation, and each of the halves is further ornamented by 4 to 6 fine striations, which are only vaguely preserved. The impression also shows that the original surface was covered by numerous faint concentric striations, but these are much less prominent than the vertical markings.

This specimen very closely resembles *K. bellatulum* but varies slightly in the ornamentation in possessing the prominent striation that bisects the flutings between adjacent ridges.

Occurrence.—Pike Arm formation: Black argillite on Burnt Island, Goldson Arm. (Twenhofel collection.)

ARMENOCERAS sp.
Plate 29, figure 22

The collections from the Natlins Cove formation of White Bay include one fragmental cephalopod that has the siphuncular structure of an actinoceroid. The fragment is 5 cms long and originally was at least 6 cms in diameter. The siphuncle ranges in diameter from 10 to 15 mm in a length of 35 mm and is composed of 10 chambers. The septa, which are poorly preserved, are equally spaced at intervals of about 3.5 mm. The siphuncle is nummuloidal, with the diameter about 15 mm in the camerae and not over 9 mm at the sutures. The specimen is too fragmental and poorly preserved to attempt specific identification, but it seems to bear closest resemblance to the genus *Armenoceras*.

Occurrence.—Natlins Cove formation: Zone D on north shore of Jacksons Arm, White Bay. (Princeton collection.)

ARTHROPODA
TRILOBITA
BUMASTUS sp.

Among the trilobites from the Newfoundland Silurian is a small distorted pygidium that is probably referable to some species of *Bumastus*. Originally it was about 24 mm wide and 8.5 mm long. The right side has been crushed and foreshortened, and the left side is partly broken away, hence the above figures are only approximations. There is a gently curved and rather faintly outlined axial lobe, which is about 7 mm wide and outlined posteriorly from the front of the pygidium for about 2.5 mm. The posterior margin is uniformly curved.

Occurrence.—Pike Arm formation: Fossiliferous argillite on Fossil Point, Pike Arm. (Twenhofel collection.)

GOLDIUS NEWFOUNDLANDENSIS Shrock and Twenhofel, n. sp.
Plate 27, figure 13

This species is based on a single pygidium, which shows the end of the central lobe and evidently is nearly entire. The pygidium is about 14 mm wide and 12 mm long. The central lobe is about 3 mm wide at the anterior extremity, whence it extends posteriorly upon the surface of the pygidium for about 3 mm and then descends rather abruptly to the central rib of the pygidium with a considerable narrowing. This central rib seems to be the widest of the 11 that are present on the pygidium. There are five lateral ribs on each side, and these originate from positions tangent to the central lobe and extend to the lateral border. The posterior rib on each side is narrower than the other four. The four anterior ribs on each side are about 1.25 mm wide, and each is separated from those adjacent by narrow rounded depressions. Rounded microscopic annulations cross the ribs.

This species resembles *G. insularis* (Billings) from the Chicotte formation of Anticosti, which has about the same dimensions, but differs in having eight ribs on each side of the central rib (instead of four as in *G. newfoundlandensis*) and a much different termination to the central lobe.

Occurrence.—Sheared limestone in Besom Cove West, New Bay of Notre Dame Bay. (Holotype in the Princeton collection.)

DICRANOPELTIS NORRISENSIS Shrock and Twenhofel, n. sp.
Plate 30, figure 11

Included in the fossils from the Goldson conglomerate at Martin Eddy Point, Exploits River, is a fragmental cranidium of a young *Dicranopeltis*. The specimen consists of the anterior lobe of the glabella and the first pair of anterior lateral lobes. Although bearing some resemblance to *D. decipiens* Winchell and Marcy, it is not that species and is herewith described as new.

The anterior lobe of the glabella is sharply separated from the first pair of anterior lateral lobes by two deeply incised first glabellar furrows. The anterior lobe of the glabella has its sides parallel until the front of the anterior lateral lobe is reached, where it rapidly expands in width so that its front margins extend nearly to the lateral margins of the anterior lateral lobes, thus giving an anchor shape to the anterior part of this lobe. The anterior lobe is 1.5 mm wide between the anterior lateral lobes and about 3.5 mm wide anteriorly. It has a length of about 4 mm. The anterior lateral lobes are 2.5 mm long parallel to the length of the cephalon and about 1.75 mm wide. The surfaces of the three lobes are covered with

small tubercles of several sizes. These do not seem to be arranged in any systematic manner. The width of the specimen across the lateral lobes is about 5 mm.

Occurrence.—Goldson formation: Conglomerate at Martin Eddy Point, Exploits River. (Holotype in Twenhofel collection.)

ENCRINURUS ANTICOSTIENSIS Twenhofel
Plate 30, figures 15, 21–23

Encrinurus anticostiensis TWENHOFEL, *1927*, Canada Geol. Survey, Mem. 154, geol. ser. 135, p. 330, pl. 59, figs. 6–10.

This species is common in the black argillites on Burnt Island, Goldson Arm, where three fairly complete specimens, 20 fragmental or partly complete pygidia, and eight fragmental cephala were collected. Two of the nearly complete specimens are enrolled and one is stretched out full length.

The Newfoundland specimens are essentially identical with the Anticosti forms, differing from them in only a few minor details. They are slightly smaller (entire length, 40 mm; length of cephalon, 10–18 mm; width of cephalon, 7–12 mm; length of thorax, 17 mm; width of thorax, 10 mm; length of pygidium, 10–14 mm; width of pygidium, 8–12 mm tapering to about 2 mm at the base of the small caudal spine); the nodes of the axial ridge are not as well developed, and in two individuals they are paired at about the mid-point of the axial ridge; and prominent rounded nodes on the axial ridge of the thorax are differently disposed in several specimens, but this change in arrangement apparently has no important significance.

E. anticostiensis differs from *E. ornatus* Hall and Whitfield, the only American species with which it might be confused, in having but a single row of nodes along the outer margin of the pleural lobes rather than three or four rows.

Occurrence.—Goldson formation: Conglomerate at Martin Eddy Point, Exploits River (two specimens). Pike Arm formation: Black and coralline argillites on Burnt Island, Goldson Arm; fossiliferous argillite and outer coral zone on Fossil Point, Pike Arm. (Princeton and Twenhofel collections.)

CALYMENE NIAGARENSIS Hall
Plate 30, figure 14

This characteristic Silurian trilobite is represented in the fauna from Burnt Island by a single well-preserved cranidium, 21 mm wide at the base and 11 mm long. The glabellar lobes and furrows are well defined, and the facial sutures and other surface features are clearly shown.

Occurrence.—Pike Arm formation: Black argillite on Burnt Island, Goldson Arm. (Twenhofel collection.)

EOPHACOPS NEWFOUNDLANDENSIS Shrock and Twenhofel, n. sp.
Plate 30, figures 16–20

In the fauna from the black argillite of Burnt Island are 4 specimens of a phacopid trilobite which do not agree in all details with any described species. Two of the specimens are incomplete enrolled individuals and represent the internal impressions of the test; the third is a fragmental pygidium which appears to be similar to the other two; and the fourth is a fragmental cranidium. There are also some other fragments.

The cephalon is about 11 mm long, 20 mm wide, highly convex, and with rounded genal angles. The gently convex glabella is shaped like a keystone and measures, in the best specimens, about 10 mm long, 9 mm wide at the anterior extremity and 4 to 5 mm at the posterior extremity in front of the occipital groove. It is separated from the fixed cheeks by a prominent longitudinal groove and is smooth except for faintly depressed glabellar furrows. The first, second and third glabellar lobes are coalesced to form the main part of the glabella, so that the first and second glabellar furrows are shallow inward and anteriorly directed grooves, which do not extend to the margin of the glabella. The third glabellar furrow extends inward, gradually shallowing almost to the medial line of the glabella, but does not join the extremity of the opposite furrow, although the necklike posterior end of the glabella becomes lower. The furrow as a whole is directed anteriorly. The fourth, or occipital furrow is continuous across the cephalon and produces a prominent constriction, so that the rest of the glabella ap-

pears to be supported on a small pedestal with a flaring base. Between the junction of the third glabellar furrow and the occipital furrow is a small node about 1 mm in diameter. The occipital lobe is not preserved in its entirety, but it is sharply separated from the rest of the cephalon by the occipital furrow. The fixed cheeks are not completely preserved but appear to be subtriangular in shape with prominent palpebral lobes. The cheeks are as high as the adjacent glabella. The large eye is 6 mm long, 3 mm wide, and 2 mm high and is shaped like the frustrum of a cone but is slightly broader anteriorly. It has 143 rounded facets in 18 vertical rows. The eye surface slopes rather steeply and uniformly from the edge of the palpebral lobe laterally. The main part of the eye is very gently convex, and the anteroposterior surface is gently curved. The anterior extremity of the glabella does not overhang the anterior margin of the cephalon, but is separated therefrom by a shallow groove, which extends across the entire front of the cephalon.

The thorax is not completely preserved, but it has at least nine segments.

The pygidium is about 9 mm long, 14–17 mm wide, and is subelliptical. The axial ridge, which has seven lobes, extends to within 1 mm of the posterior extremity of the pygidium, tapering from a width of about 5 mm to about 3 mm at its rounded extremity. It is strongly convex and separated from the pleural lobes by strong longitudinal furrows. There are seven pleural segments. The pleurae are quite distinct anteriorly but become obscure about two thirds of the length posteriorly.

Eophacops newfoundlandensis seems closest to the Anticosti *E. orestes*, from which it differs in being somewhat larger, in having a slightly differently shaped and marked glabella, larger eyes with 9 instead of 4 facets per vertical row, and more facets *in toto*, and in having a larger pygidium with a less tapering axial ridge.

Occurrence.—Goldson formation: Fragment in conglomerate at Martin Eddy Point, Exploits River. Pike Arm formation: Associated with *Encrinurus anticostiensis* and *Calymene niagarensis* in the black argillite on Burnt Island, Goldson Arm; fossiliferous argillite on Fossil Point, Pike Arm. (Holotype and supplementary material in Twenhofel collection.)

OSTRACODA

LEPERDITIA cf. L. SELWYNI Billings

Plate 30, figure 5

The dimensions of the best preserved of the two specimens follow: Length (over all), 9.5 mm; length of hinge line, 7.0 mm; height, 7.0 mm; thickness (approximate), 3.5 mm.

The shell is smooth except for a very small finely pitted area on one valve (probably a place of bryozoan attachment). No eye spot is apparent. The shell closely resembles *L. selwyni* from the Clinton of Anticosti, and the two specimens are provisionally referred to that species.

Occurrence.—Pike Arm formation: Black argillite on Burnt Island, Goldson Arm. (Twenhofel collection.)

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EOCENE AND PALEOCENE TURRITELLIDAE OF THE ATLANTIC AND GULF COASTAL PLAIN OF NORTH AMERICA

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ABSTRACT—Forty-one species and nine subspecies of *Turritella* and eleven species of *Mesalia* are described. The Turritellas fall into five major groups—the unicostate (two species), the cingulate (seven species and two subspecies), the bicostate (three species), the tricostate (five species and four subspecies, of which three species and one subspecies represent the subgroup of *T. mortoni*), and the multicostate (eleven species and two subspecies, of which seven species represent the subgroup of *T. humerosa*). Four species of *Turritella* are not classified. Eight species and six subspecies of *Turritella* and four species of *Mesalia* are described as new.

IN THE Tertiary deposits of eastern North America there is no genus of gastropod more widespread than *Turritella*, either geographically or stratigraphically. Recognizable members of the genus have been recovered in abundance from almost all horizons from northern Mexico to Maryland and Virginia. Their presence in many collections of fossils and the great diversity shown in their whorl profiles, apical angles, and sculpture patterns make them ideal for stratigraphic correlation. An attempt has been made in this paper to study the members of this great genus critically, and to determine the stratigraphic limits of the many species in the Gulf and Atlantic Coast Eocene and Paleocene.

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The family Turritellidae comprises one of the dominant groups of gastropods in the Tertiary deposits of the Atlantic and Gulf Coastal Plain. Unlike some of the dominant molluscan groups of the Eocene, the Turritellas had already become well established members of the coastal faunas before the close of the Cretaceous. The family can be traced back in geologic history at least as far as the Pennsylvanian, with closely related forms occurring much earlier in the Paleozoic. Knight (1934), who discussed the Pennsylvanian members of the family, referred the genera *Orthonema* Meek and Worthen and *Acanthonema* Grabau to the Turritellidae. This is our earliest record of the family, sensu stricto.

The ancestral history of the Turritellidae is obscure, but the group probably arose from some member of the Cambrian-through-Carboniferous family Murchisoniidae. Donald (1900) considered the group of recent Turritellas typified by *T. runcinata* Watson and characterized by a deep sinus in the outer lip, as closely related to the Murchisoniidae, and she created the new section *Colpospira* to accommodate this primitive group of Turritellas. As she pointed out, however, nothing is known of the internal anatomy of these recent forms, and they may prove to be not as primitive as their superficial resemblance to the Murchisoniidae would indicate. Randles (1900) made an anatomical study of *Turritella communis* Risso, and on the basis of this work he arrived at the conclusion that the Turritellidae were moderately highly developed gastropods with very few primitive characters, and that they approach more or less closely the Cerithiidae in anatomical structure. *T. communis*, however, bears merely a shallow sinus on the outer lip, and is apparently not closely related to *T. runcinata*, which leaves Miss Donald's postulation of primitive characters for her *Colpospira* still tenable.

Whether or not the limits of the family are broad enough to include these Paleozoic forms and their supposedly related Recent species has no bearing on the Tertiary Turritellas and their interrelationships, but certainly these forms from the Paleozoic that bear a close resemblance, at least superficially, indicate that the roots of the family penetrate deeply into geologic history.

The limits of the family Turritellidae have been variously interpreted by authors. For the purposes of this paper, which has a limited stratigraphic and geographic scope, I am considering only the two genera, *Mesalia* and *Turritella*, omitting any discussion of the less closely allied *Vermicularia*.

DESCRIPTION OF TURRITELLA

Genus TURRITELLA Lamarck, 1799

Turritella LAMARCK, *1799*, Soc. d'histoire nat. Paris, Mem., p. 74.

Haustator MONTFORT, *1810*, Conchyliologie systématique, vol. 2, pp. 182–184. Type by monotypy: *Haustator gallicus* Montfort = *Turritella imbricataria* LAMARCK. Eocene of the Paris Basin NOT GRAY, 1842 (= *Torcula* Gray, 1847).

Proto DEFRANCE, *1824*, Tableau des corps organisés fossiles, p. 114 (nomen nudum).—DEFRANCE, *1824*. Dist. sci. nat., vol. 32, p. 228. Type by monotypy: *Proto terebralis* DEFRANCE. Eocene of the Paris Basin. Not LEACH, *1813*, Crustacea.

Zaria GRAY, *1840*, Synopsis contents British Museum, 42d ed., p. 147 (nomen nudum).—GRAY, *1842*, idem, 44th ed., p. 60 (valid genus without species).—GRAY, *1847*, Zool. Soc. London, Proc. for 1847, p. 155. Type by subsequent designation: *Turbo duplicatus* Linnaeus. Recent in the Indian Ocean.

Archimediella SACCO, *1895*, I molluschi dei terreni terziarii del Piemonte e della Liguria, pt. 19, p. 12. Type by original designation: *Turritella archimedis* Brongniart (not Dillwyn) = *Turritella cochlias* Bayan. Eocene of Italy.

Torculoidella SACCO, *1895*, idem, p. 28. Type by original designation: *Turbo varicosa* Brocchi. Pliocene of Italy.

Colpospira DONALD, *1900*, Malacol. Soc. London, Proc., vol. 4, p. 51. Type by original designation: *Turritella runcinata* Watson. Recent off Australia.

Platycolpus DONALD, *1900*, Malacological Soc. London, Proc., vol. 4, p. 54. Type by original designation: *Turritella* (*Colpospira?*) *quadrata* Donald. Recent off Tasmania and Australia.

Peyrotia COSSMANN, *1912*, Essais de paléoconchologie comparée, vol. 9, p. 119. Type by original designation: *Turritella desmarestina* Basterot. Miocene of Europe.

Gazameda IREDALE, *1924*, Linnaean Soc. New South Wales, Proc., vol. 49, p. 247. Type by original designation: *Turritella gunnii* Reeve. Recent off Australia.

Ctenocolpus IREDALE, *1925*, Australian Museum, Records, vol. 14, no. 4, p. 267. Type by original designation: *Turritella australis* Lamarck. Recent off Australia.

Zeacolpus FINLAY, *1926*, New Zealand Inst., Trans., vol. 57, p. 388. Type by original designation: *Turritella vittata* Hutton. Recent off New Zealand.

Stiracolpus FINLAY, *1926*, idem, vol. 57, p. 389. Type by original designation: *Turritella symmetrica* Hutton. Recent off New Zealand.

Maoricolpus FINLAY, *1926*, idem, vol. 57, p. 389. Type by original designation: *Turritella rosea* Quoy and Gainard. Recent off New Zealand.

Spirocolpus FINLAY, *1926*, idem, vol. 57, p. 388. Type by original designation: *Turritella waihaoensis* Marwick. Eocene of Australia.

Torquesia DOUVILLÉ, *1929*, Paleontologia Indica, Mem., new ser., vol. 10, mem. 3, p. 55. Type by original designation: *Turritella granulosa* Deshayes. Eocene of the Paris Basin.

Turricula DOUVILLÉ, *1929*, idem, p. 55. Type by original designation: *Turritella hybrida* Deshayes. Eocene of the Paris Basin. Not *Turricula* Schumacher, 1817.

Tropicolpus MARWICK, *1931*, Geol. Survey New Zealand, Paleontological Bull. 13, p. 93. Type by original designation: *Turritella albolapis*

Finlay = *Turritella concava* Hutton. Miocene of New Zealand.

Spire high, more or less gradually tapering. Protoconch calcareous, smooth, glassy, turbinate; original mamilla adherent, enveloped by succeeding whorls; whorls of protoconch usually about one and one-half in number; contact with initial whorl of conch unmarked by a transverse varix or rib. Whorls of conch numerous, usually straight-sided or slightly rounded, occasionally concave, never highly inflated; sculpture appearing gradually after inception of initial whorl of conch, always consisting of spiral lirae, their number, size and position on the whorl varying greatly; basal lira sometimes modified into a strong anterior carination; posterior lira sometimes strengthened into a strong subsutural collar. Incrementals usually strong, sharply recurved, reflecting a marked sinuosity of the outer lip, the position and size of the sinus varying greatly. Operculum multispiral, not paucispiral as in *Mesalia*.

Type by monotypy: *Turbo terebra* Linnaeus. Recent in the Western Pacific.

The genus *Turritella* was erected by Lamarck in 1799 to accommodate *Turbo terebra* Linnaeus, which differed from the typical Turbos in its elongated spire and more or less sinuated outer lip. Since the erection of this genus many superspecific designations have been proposed for the members of the Turritellidae. In 1810 Montfort described the genus *Haustator*, with *Haustator gallicus* Montfort (= *Turritella imbricataria* Lamarck) of the French Eocene as the genotype. Gray, in 1842, proposed three new divisions of the genus, *Zaria*, *Haustator*, and *Mesalia*, introducing *Torcula* in 1847 to replace *Haustator* Gray, 1842, not Montfort, 1810. Of these superspecific groups of Gray, the genus *Mesalia* is now recognized as valid, fundamentally differing from *Turritella* in the sinuosity of the outer lip. The separation of *Zaria* and *Torcula* from *Turritella* was based on the profile of the whorls and the shape of the aperture. Sacco proposed the subgenera *Archimediella* and *Torculoidella* in 1895, basing his distinctions on the sculpture and form of the whorls. Miss Donald (Mrs. Longstaff) utilized the sinus of the outer lip as her criterion in creating two new sections of the genus *Turritella*, *Colpospira* and *Platycolpus*. Cossmann, in 1912, proposed a new section, *Peyrotia*, characterized by slight differences in the whorl profile and the sculpture. Douvillé, in 1930, erected two new subgenera, *Torquesia* and *Turricula*, the first of which only is nomenclatorially valid, *Turricula* having been utilized several times before in the literature. Iredale and Finlay have introduced numerous generic and subgeneric names to accommodate the Recent and Tertiary Turritellidae of the Australian province, basing their taxonomic separation more on geographic isolation than on fundamental biologic concepts.

The attempts to determine what characters in the Turritellidae can be assigned definitive values in superspecific taxonomy have so far resulted in little but confusion. Authors have utilized the apical angle, sculpture, shape of aperture and whorl profile as criteria in erecting their genera and subgenera, but all these seem artificial. The great difficulty in determining what characters may safely be utilized in establishing superspecific groups lies in our almost complete ignorance of the relationship between the anatomy and shell characters in the Recent members of the family. There has been very little work done on the correlation of these two factors, and until we have a firmer foundation for our classification of the Turritellidae, I am recognizing in the taxonomy none of the proposed subgeneric groups. In this I am following the example of both Louis Guillaume and Charles Merriam, whose recent attempts at establishing the genetic relationships of the members of the Turritellidae have been the most successful to date.

Guillaume (1924) proposed a new system of classification for the divisions of the genus *Turritella*, utilizing the sinuosity of the outer lip and its reflection in the growth lines as his sole taxonomic criterion. This is certainly a more fundamental distinction than many that had previously been employed, directly involving, as it does, the anatomical structure of the animal itself. Guillaume recognized five groups in the genus Turritella as follows:

Lignes d'accroissement présentant *deux points d'inflexion:*

1. Vers le ⅓ antérieur et le ⅓ postérieur des tours.....Groupe de *T. hybrida*
2. Vers le ⅓ antérieur et le ⅓ postérieur des tours. Trace nettement dissymétrique.. .....G. d. *T. imbricataria*
3. Au voisinage des sutures. Tracé offrant un axe de symétrie....G. d. *T. subangulata*

Lignes d'accroissement présentant *un seul point d'inflexion:*

4. Très rapproché de la suture postérieure. Stries fortement et largement incurvées .....G. d. *T. terebralis*
5. Stries faiblement arquées...G. d. *T. turris*

While this classification of Guillaume's is excellent and extremely useful in aligning the members of the genus *Turritella* throughout the world, its application to the Eocene Turritellas of eastern North America is limited, inasmuch as they are all within the limits of the group of *Turritella hybrida*. As Woodring (1928, p. 348) has pointed out, perfectly valid names are available for these group designations of Guillaume, *Turritella* s.s. for the group of *T. terebralis* Lamarck, *Haustator* Montfort, for the group of *T. imbricataria* Lamarck, *Archimediella* Sacco for the group of *T. turris* Basterot and *Torculoidella* Sacco for the group of *T. subangulata* Bronn. No name was available for the group of *T. hybrida* Deshayes at the time of publication of Woodring's paper, and the unfortunate selection by Douvillé (1930, p. 55) of the name *Turricula*, preoccupied several times in the literature, to designate this group, leaves the subgenus still unnamed.

Merriam (MS) accepts this classification of Guillaume, and follows the conservative policy of group designations for the definite superspecific divisions. He does, however, modify the groups recognized by Guillaume, utilizing the sculpture of the apical whorls in conjunction with the sinuosity of the outer lip. Four types of apical sculpture are recognized by Merriam, a "cingulate" type where the nuclear whorls are marked by two revolving lirae appearing simultaneously; a "bicostate" type which also bears two revolving ribs, but more narrowly spaced than in the cingulate type and more medially situated on the whorl; a "tricostate" type with three well-defined nuclear primaries; and a "unicostate" type which exhibits only a single, more or less median, carina. This grouping is based on Merriam's study of the West Coast Tertiary species of the genus, but is readily applicable to the species present in the Eocene of the Atlantic Coast and Gulf Embayment, with the addition of one other type of apical sculpture, a "multicostate" type, with three to six subequal revolving lirae originating almost simultaneously on the early apical whorls. I have further modified this classification of Merriam's by the introduction of minor groupings under the sculpture types, based on whorl profiles and apical angles. This subgrouping is particularly evident in the Paleocene, where almost all the species present seem allied to one of two types, the groups of *Turritella mortoni* Conrad and *Turritella humerosa* Conrad. The group of *T. mortoni* includes the basally carinate species with a rather abrupt tapering of the spire, and the group of *T. humerosa* comprises those species with a subsutural collar, multicostate apical whorls, and a very gradually tapering spire. This obvious grouping of the Paleocene species is less evident in the Eocene, where there is a much greater diversification of form and sculpture. The postulate relationships of the members of the *T. humerosa* and *T. mortoni* groups are shown in the tables on pages 271 and 272.

The alignment of the Eastern Eocene species in the sculpture groupings of Merriam is shown below:

I. Unicostate group
   - *apila* DeGregorio
   - *arenicola* Conrad

II. Cingulate group
   - *rina* Palmer
   - *rina subrina* Palmer
   - *rina carolina* Palmer
   - *cortezi* Bowles, n. sp.
   - *wechesensis* Bowles, n. sp.
   - *vaughani* Bowles, n. sp.
   - *martinensis* Dall
   - *subtilis* Kellum
   - *rivurbana* Cooke

III. Bicostate group
   - *tennesseensis* Gabb
   - *dutexata* Harris
   - *lisbonensis* Bowles, n. sp.

IV. Tricostate group
   - *nasuta* Gabb
   - *nasuta smithvillensis* Bowles, n. subsp.
   - *nasuta felli* Bowles, n. subsp.
   - *nasuta houstonia* Harris
   - *eurynome* Whitfield
   - Subgroup of *T. mortoni*
     - *mortoni* Conrad
     - *mortoni mediavia* Bowles, n. subsp.
     - *mortoni postmortoni* Harris

alabamiensis Whitfield
levicunea Harris
hilli Gardner
gilberti Bowles, n. sp.
dumblei Harris
dumblei turneri Plummer
carinata Lea
carinata palmerae Bowles, n. subsp.
alveata Conrad
perdita Conrad
clevelandia Harris

V. Multicostate group
saffordi Gabb
potomacensis Clark and Martin
obruta Conrad
pleboides Vaughan
Subgroup of *T. humerosa*
humerosa Conrad
humerosa biboraensis Gardner
humerosa sanjuanensis Bowles, n. subsp
claytonensis Bowles, n. sp.
aldrichi Bowles, n. sp.
multilira Whitfield
bellifera Aldrich
praecincta Conrad
mcbeanensis Bowles, n. sp.

VI. Incertae sedes
mingoensis Bowles, n. sp.
ola Plummer
kincaidensis Plummer
lowei Cooke

STRATIGRAPHIC DISTRIBUTION OF THE EAST AMERICAN SPECIES OF *Turritella*

Midway group (Paleocene).—The genus *Turritella* is first recognized with certainty in the Triassic, but its maximum development was attained in the Upper Cretaceous and Tertiary. Before the close of the Cretaceous in North America the genus had become extremely abundant and diversified, and it is not surprising that *Turritella* was one of the dominant gastropod genera in the Paleocene of the Gulf embayment. Twelve species and subspecies are recorded from deposits of Midway age, most of them falling into two groups, the basally carinate species typified by *T. mortoni* (see table 1) and the slender forms with subsutural collars typified by *T. humerosa* (see table 2). In the first grouping we find *Turritella mortoni mediavia* Bowles, n. subsp., and *T. alabamiensis* Whitfield of the east Gulf region and *T. hilli* Gardner of the Texas Midway. The occurrence in the Black Mingo formation of South Carolina of well-preserved specimens of *T. mortoni mediavia*, identical in every way with the type material from the Clayton limestone of Alabama, is as strong evidence of the Midway age of the Black Mingo as that on which the formation was assigned to the Wilcox by Cooke (1936, pp. 40–42).

The *Turritella humerosa* stock is represented in the Midway by *T. claytonensis* Bowles, n. sp., *T. aldrichi* Bowles, n. sp., and *T. biboraensis* Gardner. *T. claytonensis* is found only in the lower Midway Clayton limestone of the eastern Gulf, and *T. biboraensis* is restricted to the Kincaid formation of the Rio Grande embayment. *T. aldrichi* continues throughout the Midway of Alabama, and is the only representative of the *T. humerosa* stock recovered from deposits of upper Midway age.

The relationships of the other Midway species are more obscure. *Turritella levicunea* Harris, of the lower Midway of Alabama, is a large, abruptly tapering form

TABLE 1. POSSIBLE PHYLOGENY OF THE TURRITELLA MORTONI SUBGROUP

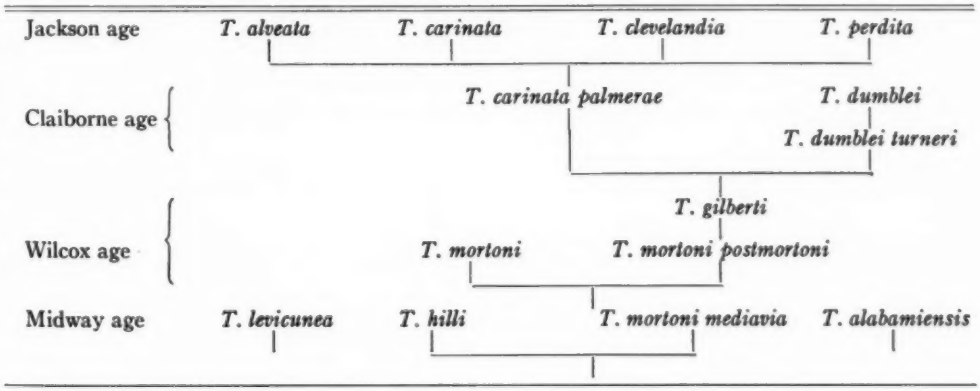
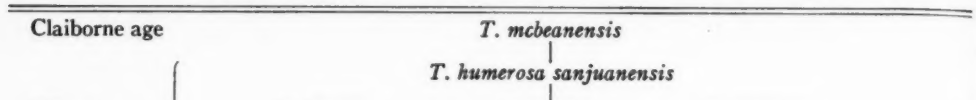


TABLE 2. POSSIBLE PHYLOGENY OF THE TURRITELLA HUMEROSA SUBGROUP



that seems to be allied to the *T. mortoni* stock, but whose apical whorls bear two strong and one indistinct revolving lirae as contrasted to the typical subequal tricostate sculpture of the apical whorls of *T. mortoni*. *T. kincaidensis* and *T. ola* of Plummer may also be aberrant forms in the development of the ancestral stock of *Turritella mortoni*. *Turritella mingoensis* Bowles, n. sp., from the Black Mingo formation of South Carolina, is distinct from any other form in the American Paleocene or Eocene, the bare posterior and finely sculptured anterior portions of the whorl constituting a sculpture pattern unrepeated. *T. tennesseensis* of the Clayton formation of Mississippi and Tennessee has two subcentrally situated lirae on each apical whorl, the "bicostate" type of Merriam, and is unlike any other Paleocene species.

Wilcox group (lower Eocene).—The group of *Turritella mortoni* develops amazingly in the Wilcox, with *T. mortoni postmortoni* Harris constituting one of the most important elements of the lower Wilcox faunas in both the eastern and western Gulf regions. *Turritella mortoni*, s.s., is restricted to the Aquia formation of Maryland and Virginia, but it is present in abundance at outcrops of this formation.

The *Turritella humerosa* stock shows a greater diversification in the lower Wilcox, being represented by *T. multilira* Whitfield of the Nanafalia, and the closely allied *T. bellifera* Aldrich of the Tuscahoma. *Turritella praecincta* Conrad of the lower Wilcox of Texas, Mississippi and Alabama is an aberrant form apparently derived from the *T. humerosa* ancestral stock, the subsutural collar being strongly developed into a prominent posterior carination of the whorl. *T. humerosa sanjuanensis*, n. subsp., of the lower Eocene of northern Mexico is much more closely allied to *T. humerosa*, s.s., than are the Alabama representatives of the group. *T. humerosa* Conrad, s.s., is found only in the Aquia formation of Maryland and Virginia, in association with but considerably less common than *T. mortoni*.

In addition to these major lower Eocene groups there are several other species whose relationships are less easily determined. *T. eurynome* Whitfield, of the Alabama Tuscahoma, characterized by four or five very strong subequal revolving lirae on each whorl, has the apical sculpture pattern of the *Turritella mortoni* group, but there is no sign of a basal carination, and the straight-sided, multilirate adult whorls seem more closely allied to *T. humerosa*. *T. potomacensis* Clark & Martin, recovered only from the Nanjemoy formation of Maryland and Virginia, and but sparingly represented in these deposits by poorly preserved material, has the apical sculpture of the *T. humerosa* group, but the whorls are developed anteriorly into an obscure basal carination.

The upper Wilcox yields only one species of *Turritella*, *T. gilberti* Bowles, n. sp., restricted to the Bashi formation and constituting a prominent element of some of the Alabama Bashi faunas. This species, although but obscurely carinate anteriorly, seems to be a continuation of the *Turritella mortoni* stock and perhaps constitutes a link between the lower Wilcox and Claiborne members of the group.

Claiborne group (middle Eocene).—In the Claiborne of the eastern Gulf province the *Turritella mortoni* stock is represented by

a single subspecies, *T. carinata palmerae* Bowles, n. subsp. of the Lisbon formation of Alabama. This form differs but slightly from typical *T. carinata* Lea of the Moodys marl,[1] but the differences are constant and the stratigraphic distribution of the two forms seems to justify their subspecific separation. In the western Gulf there are two forms apparently derived from the *T. mortoni* stock of the Wilcox, *T. dumblei* Harris of the Cook Mountain formation, and the closely allied *T. dumblei turneri* Plummer, confined to the Reklaw member of the Mt. Selman formation. The basal carination of these Texas forms is much less pronounced than in typical Wilcox members of the group, but a relationship is certainly indicated.

The *Turritella humerosa* stock is represented in the Claiborne by a single species of very limited geographic range, *T. mcbeanensis*, n. sp., recorded only from the McBean formation of Georgia and South Carolina. Like *T. humerosa*, this species is characterized by a subsutural swelling of the whorl. *T. mcbeanensis* marks the decline of the *T. humerosa* race in the east American Eocene.

A prominent group recorded only from the Claiborne group but extremely abundant in deposits of that age, is the *Turritella rina* Palmer group, differing from the *T. mortoni* stock in the cingulate sculpture of the apical whorls. In its adult stages *T. rina* superficially resembles *T. carinata* Lea in the strong basal carination of its whorls, but the associated subspecies, *T. rina carolina* Palmer and *T. rina subrina* Palmer, as well as the allied species, *T. cortezi* Bowles, n. sp., of the south Texas-north Mexico Claiborne, duplicate the bicostate apical sculpture of *T. rina*, s.s., with no indication of a basal carination. Apparently these four forms constitute a separate, short-lived group, possibly derived from some *mortoni*-like ancestor. *Turritella cortezi* is an excellent horizon marker in the south Texas region, having a very limited stratigraphic range, confined to the upper part of the Cook Mountain formation in La Salle, Webb and Zapata Counties and continuing across the Rio Grande into Tamaulipas and Nuevo León.

Turritella vaughani Bowles, n. sp., a unique form from the McBean formation of South Carolina, is also marked by a cingulate type of apical sculpture, but the two prominent revolving lirae persist unchanged throughout the growth of the shell, and they are not augmented on the adult whorls by any secondary lirae. The slender form of the spire distinguishes this species from the members of the *T. rina* group.

Concurrent with the decrease in prominence of the *T. mortoni* and *T. humerosa* groups in the Claiborne is the appearance of an extremely virile race, that of *Turritella nasuta* Gabb, the most abundant and widespread of the Claiborne Turritellas. The origin of this race is obscure, the apical sculpture being tricostate as in the *T. mortoni* group, but the spire is very gradually tapering, and the whorls are typically straight-sided with no sign of a basal carination. The *Turritella nasuta* group is particularly abundant in the western portion of the Gulf embayment, but one subspecies, *T. nasuta felli*, n. subsp., is common to the Lisbon formation of Alabama and the McBean formation of Georgia. *T. nasuta smithvillensis* Bowles, n. subsp., is the earliest recorded scion of the group, represented sparingly in the Weches member of the Mt. Selman formation, and confined to that horizon. *T. nasuta*, s.s., is recorded from the Cook Mountain formation of both east Texas and the Rio Grande embayment, apparently more restricted stratigraphically in the southern part of its range, where it marks a definite horizon low in the Cook Mountain, below the *Turritella cortezi* zone. North of La Salle County, *T. nasuta* is recorded from the so-called "Derby Zone," the basal Cook Mountain of Frio County and farther east it is present throughout much of the Cook Mountain section. In the high Cook Mountain of Houston and Lee Counties, *T. nasuta houstonia* Harris appears, but it is not an abundant or widespread form, being found only in a few Upper Cook Mountain localities. There seems to be no continuation of this strong Claiborne group into the Jackson or younger horizons.

The other Claiborne Turritellas are ap-

[1] The Gosport sand of Alabama is identified by Cooke (1939) as Moodys marl.

parently not closely allied to those major groupings already discussed. *Turritella pleboides* Vaughan, recovered only from deposits of Claiborne age in Louisiana, is a small species with very inflated whorls, superficially resembling *Mesalia* but with the distinctive recurved incrementals of *Turritella*. *T. wechesensis* Bowles, n. sp., a singular form from the Weches member of the Mt. Selman formation of east Texas, resembles *T. rina* in its apical sculpture, with two widely spaced, prominent revolving lirae on the early whorls. With continued growth, however, this strong early sculpture becomes constantly less prominent until it is almost invisible on the body whorl of adult specimens. Whether or not it is an aberrant form derived from a common ancestor with the *T. rina* stock is unknown, but the similarity of the apical sculpture of the two species would so indicate.

Turritella dutexata of the Texas Weches and the apparently related *T. lisbonensis*, n. sp., of the McBean formation of South Carolina and the Lisbon formation of Alabama are characterized by two closely-spaced lirae on each apical whorl, the bicostate division of the Merriam classification. *T. tennesseensis* of the Midway is the only other East American early Tertiary species with a comparable apical sculpture, and it is possible that this Paleocene form represents an early ancestor of the bicostate lower Claiborne species, although such a suggestion is pure speculation.

Jackson group (upper Eocene).—The extremely abundant and variable *Turritella carinata* Lea of the Moodys marl of Alabama (Cooke, 1939) is a continuation of the basally carinate *T. mortoni* stock into the Jackson group, and this common species is probably directly derived from the very similar Claiborne subspecies *Turritella carinata palmerae*. The basal carination of *T. carinata* is not always strongly developed, and Mrs. Palmer (1937, p. 191) utilized the name *Turritella ghigna* DeGregorio for those individuals with a barely perceptible keel, although she recognized that the two extreme forms constituted end members of a continuous series. Vaughan[2] has estimated that there are 2560 possible distinct variations of *T. carinata*, considering all the combinations of whorl profile, apical angle and sculpture. *Turritella carinata* is recorded only from deposits of Jackson age, however, and since the variations have no stratigraphic significance they are all here included under a single name.

Three other common species of the Jackson group, *Turritella alveata* Conrad, *T. perdita* Conrad and *T. clevelandia* Harris, have been rather tentatively placed as the culmination of the *T. mortoni* stock. They are all three marked by tricostate apical sculpture and are all slightly carinated basally. The distribution of these three species overlaps somewhat. *T. perdita* is confined to the Moodys marl of Mississippi, with a doubtful occurrence in Louisiana, while *T. alveata*, with which *T. perdita* is associated at Jackson and other Mississippi localities, is also recorded from Arkansas and Louisiana. *T. clevelandia* is known only from the western Gulf, and is especially abundant in Arkansas.

The unicostate group of the Merriam classification first appears in the Jackson of the eastern Gulf province, represented by the distinctive species *T. apita* DeGregorio, which is confined to the Moodys marl of Alabama. This species is characterized by an extremely prominent median carina that persists throughout the growth of the shell, augmented on the adult whorls by accessory lirae but always maintaining its relative prominence. The possible antecedents of this unicostate group are unknown.

Turritella arenicola, the most widespread of the Jackson Turritellas, strongly resembles *T. apita* in its unicostate apical sculpture, although differing widely in its multistriate adult whorls.

Turritella obruta Conrad, found only in the Moodys marl of Alabama, is a *Mesalia*-like form, somewhat resembling *Turritella pleboides* of the Louisiana Claiborne in its rounded, inflated whorls and abruptly tapering spire, and possibly is a derivation from that earlier form.

The cingulate group of Turritellas is represented in the Jackson by *T. martinensis* Dall of the Barnwell sand of Georgia and the Ocala limestone of Florida and Alabama, *T. subtilis* Kellum of the Castle Hayne marl

[2] Vaughan, T. W., oral communication, 1938

of North Carolina, and *T. rivurbana* Cooke of the Moodys marl of Mississippi. These three species are very suggestive of the Miocene Turritellas of the group of *T. altilira* Conrad, and they probably represent the ancestral forms of this great American middle-Tertiary race. The Jackson species closely resemble *T. vaughani* of the McBean formation of South Carolina, and they may have been derived from that species.

Turritella lowei Cooke of the Moodys marl of Mississippi cannot be satisfactorily placed in any of the recognized groups of Eocene Turritellas, being distinguished by unsculptured apical whorls. The species is very limited both geographically and stratigraphically.

I. UNICOSTATE GROUP

TURRITELLA APITA DeGregorio

Plate 31, figure 4

Turritella carinata H. C. LEA, *1840*, Am. Jour. Sci., 1st ser., vol. 40, pp. 96–97, pl. 1, fig. 10. — MEYER, *1887*, Acad. Nat. Sci. Philadelphia, Proc. for 1887, p. 54, pl. 3, figs. 1, 1a. Not Isaac Lea, 1833.

Turritella apita DEGREGORIO, *1890*, Faune éocénique de l'Alabama, p. 123, pl. 11, figs. 8, 26, 27.—PALMER, *1937*, Bull. Am. Paleontology, vol. 7, no. 32, p. 195, pl. 24, figs. 1, 3, 7, 10.

Shell small. Spire gradually tapering. Whorls numerous, sharply angulated medially by a strong carina. Sutures distinct but not deeply impressed. Apical whorls marked by a single strong median carina, a less prominent accessory lira appearing anterior to it on the second or third whorl; accessory revolving lira becoming more prominent on the adult whorls, assuming almost as strong an aspect as the primary carina on the body whorl of the largest individuals; a second accessory carina, posterior to the primary, present on the oldest specimens; numerous fine revolving threads present on the entire surface of the whorls, but especially evident just behind the sutures. Incrementals strongly reflected, indicating a marked sinuosity of the outer lip. Aperture not preserved complete.

Type material: A holotype in the DeGregorio collection, Palermo, Sicily. Lectotype of *T. carinata* H. C. Lea, Academy of Natural Sciences, Philadelphia, no. 13173. Figured specimen, U. S. Nat. Mus. no. 494978.

Type locality: "Claiborne sand," Claiborne Bluff, Alabama River, Monroe County, Alabama. The type of *T. carinata* H. C. Lea and the figured specimen are topotypes. Jackson group, Moodys marl.

Henry Lea must have been under the impression that his father's *Turritella carinata* was a synonym of Conrad's *T. mortoni*, or he would hardly have reproposed the name. This view must also have been held by Isaac Lea himself, as his son was only fifteen when the paper was published, and Henry must have received considerable assistance from his father. *Turritella apita* DeGregorio seems to be the next available name for the preoccupied *T. carinata*.

Turritella apita is a very distinctive form, whose ancestral relationships are difficult to trace. The closest sculptural analogues seem to be found in the Midway Mesalias, *M. sayi* and *M. hardemanensis*, but the growth lines indicate a much more sinuous outer lip than is present in the Eocene Mesalias. The only closely related form in the Eocene is *T. arenicola* of the Jackson, a species that is also characterized by unicostate apical whorls, but this species is much larger and its adult whorls are rounded and multistriate.

Distribution.—Jackson group, Moodys marl. ALABAMA, *Monroe County:* U. S. Nat. Mus. no. 137530 and U. S. G. S. stas. 263, 2391 and 2867, Claiborne Bluff, Alabama River.

TURRITELLA ARENICOLA (Conrad)

Plate 31, figures 5–7

Turritella plebeia Say. OWEN, *1860*, Geol. Reconnaissance Arkansas, 2nd Ann. Rept., pl. 9, fig. 6. Not SAY, *1824*.

Mesalia? arenicola CONRAD, *1865*, Am. Jour. Conchology, vol. 1, p. 141, pl. 10, fig. 11.

Mesalia arenicola GABB, *1869*, California Geol. Survey Paleontology, vol. 2, p. 114.

"Mesalia" arenicola STEWART, *1927*, Acad. Nat. Sci. Philadelphia, Proc. for 1926 (vol. 78), p. 354.

Turritella arenicola CALL, *1891*, Arkansas Geol. Survey, Ann. Rept. for 1889, pt. 2, p. 8.—HARRIS, *1894*, Arkansas Geol. Survey, Ann. Rept. for 1892, pt. 2, pp. 88, 92, 169.

Turritella arenicola var. *branneri* HARRIS, *1894*, Arkansas Geol. Survey, Ann. Rept. for 1892, pt. 2, pp. 92, 93, 95, 96, 98, 169, 174, pl. 6, fig. 7.—PALMER, *1937*, Bull. Am. Paleontology, vol. 7, no. 32, p. 197, pl. 23, figs. 1, 2.

Spire high, gently tapering. Whorls numerous, sharply angulated medially in youth, more rounded and relatively higher when adult. Sutures linear but deeply impressed. Apical whorls marked by a single prominent carina situated a little anterior to the median of the whorl; a revolving lira appearing anterior to the primary carination on the sixth whorl, immediately followed on the seventh whorl by a less prominent lira just posterior to the carina; the primary carina becoming relatively less prominent with the development of the anterior secondary lira until on the ninth or tenth whorl the sculpture is strictly bicarinate, the two prominent revolving lirae being equal in strength; the posterior secondary lira gradually increasing in prominence until the eleventh and later whorls are sculptured by three subequal cords; four or five smaller accessory lirae added on the eighth and ninth whorls, rarely becoming as strong as the three earlier cords; a wide, smooth area existing between the anterior secondary lira and the suture, marked only by extremely fine revolving lines. Incrementals distinct, strongly marked on the adult whorls, deeply arcuate, the maximum flexure between the posterior third and the median of the whorl, slightly reflexed just behind the anterior suture. Parietal callus broad, distinct. Aperture rounded, outer lip very thin and fragile, not observed entire.

Dimensions: Not given by Conrad for the holotype. Figured specimens (U. S. Nat. Mus. no. 498002), height, 41.0 mm; greatest diameter, 12.0 mm. (U. S. Nat. Mus. no. 495144), height, 36.0 mm; greatest diameter, 9.0 mm.

Type material: A lectotype and two paratypes in the collection of the Philadelphia Academy of Natural Sciences. The holotype of *Turritella arenicola branneri* Harris, U. S. Nat. Mus. no. 135141. Two figured specimens, U. S. Nat. Mus. nos. 498002 and 495144.

Type locality: (according to Conrad, 1865) "Enterprise, Mississippi." Listed in his checklist (Conrad, 1866) as described from Oregon. Aldrich (1885, p. 307), in discussing Conrad's descriptions of Enterprise fossils, said:

> The species described by Conrad which were received from Dr. Spillman in which he gives the locality "Enterprise, Miss.," Dr. S. writes me (Aug. 14, 1884) were not found there; he says: "I have no recollection of sending T. A. Conrad any fossils from near Enterprise. I sent him some from Garland's Creek, three miles east of Shubuta, Miss., in the southern part of Clark County."

The locality cited by Dr. Spillman in his letter to Aldrich is a typical Jackson locality, and material from there in the collections of the U. S. National Museum coincides in every way with the description and figure of Conrad's species. There is nothing in the Claibornian beds at Enterprise that might have been confused with this form. The citing of an Oregon locality for the species in 1866 was probably a *lapsus calami* Figured specimens: (498002) U.S.G.S. sta. 330, 4.5 miles east of Shubuta, Clarke County, Mississippi (a topotype?). (495144) U. S. G. S. sta. 2602, White Bluff, Jefferson County, Arkansas, Jackson group, Moodys marl.

Turritella arenicola most closely resembles *T. dutexata* of the Claiborne, although the apical whorls of the older species are bicostate. The same characteristic bicarination of the adolescent whorls is observed in both species, but, as Harris (1895, p. 82) has pointed out, in the Texas form it is the anterior lira that persists on the apical whorls; whereas in *Turritella arenicola* it is the posterior. There is a certain amount of individual variation in the persistence of the unicarinate sculpture on the apical whorls. On some specimens the second prominent revolving rib appears as early as the third whorl, while on others it is still absent on the eighth or ninth whorls. It invariably does appear, however, and it always appears anterior to the original carination.

Turritella apita DeGregorio of the Moodys marl is the only other unicarinate *Turritella* in the east American Eocene.

In the Mexican collections there are only two individuals that show the early adolescent whorls, and these exhibit a bicarinate sculpture, but the posterior revolving lira is much the stronger, and the specimens are in every way similar to some of the material from Bradley County, Arkansas. The extreme tip of the Mexican species is unknown.

Conrad originally described this species

as "*Mesalia?*" The rounded and highly inflated whorls suggest the form of some of the Mesalias, but the strong inflection of the growth lines, which are recurved near the anterior suture, indicate a sinuosity of the outer lip more closely comparable to that of *Turritella* than to typical *Mesalia*.

Harris (1894, p. 169) described a subspecies of this form, *T. arenicola branneri* from the Jackson beds of Arkansas, saying:

> This variety differs from true *arenicola* in having fewer revolving lines, less rounded whorls, and in being of considerably smaller size.

A comparison of Harris' type material with topotypes of *T. arenicola*, s.s., shows these characters to be variable, and so I have reunited the arenicolas under a single name. Mrs. Palmer (1937, p. 197) has recognized this species from White Bluff, Arkansas, the Jacksonian age of which she questions. The material from this locality has much closer affinities with the typical Jackson of Mississippi than with any described Claibornian faunas.

The specimens figured by Owen in his report on the Geology of Arkansas are in the collections of the U. S. National Museum and prove to be *Turritella arenicola* rather than *T. plebeia* Say of the Chesapeake Miocene, as Owen determined them, although they do superficially resemble this younger species in the inflation of the whorls. This Arkansas material is catalogued in the National Museum as no. 495145.

Distribution.—Jackson group, Moodys marl. MISSISSIPPI, *Clarke County:* Garland's Creek, NE ¼ sec. 29, 4 miles north-northeast of Shubuta, U. S. G. S. stas. 330, 2630, 6471. *Yazoo County:* U. S. G. S. sta. 7393, Locust Grove Plantation, 1½ miles south of Sartartia. LOUISIANA, *Grant Parish:* U. S. G. S. sta. 2003, Creole Bluff, Montgomery; U. S. G. S. sta. 2638, Bluff at Montgomery, ¼ to ½ mile below Ferry landing. *Rapides Parish:* U. S. G. S. sta. 7743, in well from depth of 1500–1860 feet, about 2 miles northwest of Boyce; U. S. G. S. sta. 7944, in well of Cotile Oil and Gas Company near Boyce, from depth of 1500–2500 feet. ARKANSAS, *Bradley County:* U. S. G. S. sta. 2404, middle of sec. 8, T. 12 S., R. 9 W., 30 yards northwest of Lee Hamaker's house, from a bored well 30 feet below surface. *Drew County:* U. S. G. S. sta. 2408, from well at Long Prairie, W. ½ SW ¼ sec. 5, T. 14 S., R. 6 W. *Jefferson County:* U. S. G. S. stas. 2220 and 13797, White Bluff, W. ½ SE ¼ sec. 19, T. 2 S., R. 10 W. and W. ½ NE ¼ NW ¼ sec. 30, T. 3 S., R. 10 W. *St. Francis County:* U. S. G. S. sta. 4156, Big Crow Creek, Crowley's Ridge; U. S. G. S. sta. 4157, Crowley's Ridge; U. S. G. S. sta. 4266, Little Crow Creek, ¼ mile above Choctaw Bridge, Crowley's Ridge, near Forrest City. TEXAS, *Starr County:* U. S. G. S. sta. 13799, Alta Vista Ranch, 5.8 miles W. 35° N. of Rio Grande City. *Sabine County:* U. S. G. S. sta. 10516, ¼ to ½ mile below Robinson's Ferry, on the Sabine River. MEXICO, *Tamaulipas:* U. S. G. S. sta. 13504, 15.9 kilometers south 7°30′ east of Ciudad Camargo; U. S. G. S. sta. 13506, 1 kilometer north of Villa Nueva or Nuevo Camargo, Camargo sector, La Mision. *Nuevo León:* U. S. G. S. sta. 13512, 1200 feet north and 1300 feet east of Rancho la Rosita, in arroyo, Zacate district.

II. CINGULATE GROUP

TURRITELLA RINA Palmer

Plate 31, figure 17

Turritella mortoni Conrad. TUOMEY, *1848*, Geology of South Carolina, p. 159. Not CONRAD, *1830*.

Turritella carinata Lea. ALDRICH, *1886, ex parte*, Geol. Survey Alabama, Bull. 1, p. 46.

Turritella carinata var. *praecarinata* Harris. COOKE, *1936*, U. S. Geol. Survey, Bull. 867, p. 63 (Nomen nudum: Not *Turritella praecarinata* DOUVILLÉ, *1904*).

Turritella rina PALMER, *1937*, Bull. Am. Paleontology, vol. 7, no. 32, p. 192, pl. 22, figs. 3, 4, 9.

Shell large. Spire rather abruptly tapering. Whorls straight-sided in youth, becoming basally carinated when adult. Sutures linear and indistinct between the young whorls, rapidly becoming deeper with the development of the basal carination until between the adult whorls they are extremely deep and wide, thus giving a suggestion of loose coiling. Apical whorls threaded with two strong revolving lirae on the anterior half of the whorl, with a smaller revolving cord posterior to them and separated from them by a smooth, constricted area; fine accessory threading appearing early in adolescence covering the entire whorl, but

never becoming very prominent; anterior primary lira strengthening with the growth of the shell and late in adolescence forming a distinct basal carination, which becomes very strong on the adult whorls; posterior and medial primaries subequal in strength on the adult whorls, the wide space between them marked only by the fine spiral threading; under surface of basal carina sculptured only by extremely fine, indistinct lines. Incrementals distinct, deeply arcuate, attaining the maximum of their curvature between the medial and posterior carinae, strongly recurved below the basal carination. Parietal wash thickly and widely spread. Aperture not preserved entire. Outer lip heavy, but due to the chalky nature of most of the material, usually broken.

Dimensions: Holotype (as given by Palmer), height, 47.0 mm; greatest diameter, 18.0 mm. Paratypes (2868), height, 25 mm; greatest diameter, 10 mm; (2869) height, 14 mm; greatest diameter, 5 mm (juvenile specimen). Figured specimen, height, 44 mm; greatest diameter, 15 mm.

Type material: A holotype (no. 2874) and two paratypes (nos. 2868 and 2869) in the collection of the Paleontological Research Institution, Ithaca, New York. Figured specimen, U. S. Nat. Mus. no. 495170.

Type locality: Paleontological Research Institution sta. 103, lower bed at the base of the bluff, on the Alabama River at Claiborne, Monroe County, Alabama. One of the paratypes is from Sabine County, Texas, and the other from Newton County, Mississippi. The figured specimen is a topotype.

Turritella rina is the most abundant and widespread member of the Turritellidae in the Claiborne deposits of the eastern Gulf region. It is most easily confused with *Turritella carinata* Lea of the Moodys marl and its subspecies *T. carinata palmerae*, with which *T. rina* is associated in the Claiborne. The sculpture pattern of *T. rina* is typically bicarinate, but *T. carinata* is characterized by three subequal revolving lirae on the apical whorls, augmented by several accessory threads on the adult. The sutures of *T. rina*, too, are more deeply impressed, and the spire appears much more loosely coiled than that of *T. carinata*.

The name *Turritella carinata* var. *praecarinata* Harris, used by Cooke in his list of species from Caw Caw Swamp, Orangeburg County, South Carolina, was taken from a specimen in the National Museum labelled by Harris, but the description of the species was never published. The name "*praecarinata*" is preoccupied by Douvillé.

Turritella rina is recorded, judging by the collections of the National Museum, only in deposits of Claiborne age, although Mrs. Palmer reports two specimens of the species in the Harris collection from the Gosport sand (Moodys marl). There are no specimens referable to *T. rina* in the National Museum's extensive collections from the Moodys. The species is common throughout the McBean formation of South Carolina and Georgia, the Lisbon formation of Alabama and Mississippi, and the St. Maurice formation of Louisiana. Mrs. Palmer records *T. rina* from Sabine County, Texas, and from Smithville in Bastrop County, but the collections of the National Museum contain no basally carinate forms from the Weches of the western Gulf.

Distribution.—Claiborne group, McBean formation. SOUTH CAROLINA, *Aiken County:* U. S. G. S. sta. 4603, Hixon Bridge, Tinker's Creek, public road 200 feet east of bridge, 12½ miles west of Williston. *Lexington County:* U. S. G. S. sta. 7731, property of Eugene Senn, north of Kennerly road, Lexington-Calhoun county line, ¼ mile north of house, 7 miles east of Swansea. *Williamsburg County:* U. S. G. S. sta. 7920, roadside, 1.1 miles southeast of Salters. GEORGIA, *Burke County:* U. S. G. S. sta. 5296, Sloan's Scarp, McBean Creek.

Claiborne group, Lisbon formation. ALABAMA, *Monroe County:* U. S. G. S. stas. 2395, 2396 and 12171, lowest bed at Claiborne Bluff, Alabama River; U. S. G. S. stas. 3105 and 5511, Lisbon Bluff, Alabama River; U. S. G. S. sta. 13431, bed no. 7 of the Cooke section, Lisbon Bluff, Alabama River. *Clarke County:* U. S. G. S. sta. 12181, cliff at Coffeeville, Tombigbee River. *Conecuh County:* U. S. G. S. sta. 6737, east side of Sepulga River on land of J. G. Robinson, sec. 13, T. 4 N., R. 13 E. MISSISSIPPI, *Clarke County:* U. S. G. S. stas. 338, 2616, 3092, and 6479, Wautubbee Hills, railroad cut 4½ miles southwest of Enterprise; U. S. G. S. sta. 2621, in wash of Rose Hill Road, 8 miles west of Enterprise; U. S.

G. S. sta. 2622, in wash of old Enterprise road, at residence of Mr. J. Harrison Johnson, 8 miles south of Hickory and 12 miles northwest of Enterprise; U. S. G. S. sta. 2623, in a washed off place in Mr. J. H. Johnson's farm, south of the creek and about 9½ miles south of Hickory. *Newton County:* U. S. G. S. sta. 2618, in wash of road from Newton to Decatur, about 3 miles northeast of Newton in hill going down to Pottoxchitto Creek; U. S. G. S. sta. 2620, Indian mound railroad cut on the side of Pottoxchitto swamp, 4½ miles east of Newton; U. S. G. S. sta. 2624, in wash of old Enterprise road, going down the hill to the Pottoxchitto swamp, 2 miles southeast of Hickory; U. S. G. S. sta. 2625, in wash of the old General Jackson road from Nashville, Tennessee to New Orleans, 1 mile south of Hickory.

Claiborne group, St. Maurice formation. LOUISIANA, *Winn Parish:* U. S. G. S. stas. 2005, 2916, and 4272, Saline Bayou, St. Maurice.

TURRITELLA RINA SUBRINA Palmer
Plate 31, figure 16

Turritella rina subrina PALMER, *1937*, Bull. Am. Paleontology, vol. 7, no. 32, p. 194, pl. 22, figs. 1, 2, 5, 7, 8, 10, 11.

Shell large, robust. Spire high, rather abruptly tapering. Whorls numerous, wider than high, particularly in the adult stages; not rounded. Sutures linear and indistinct between the apical whorls, becoming more distinct but no wider and not much more deeply impressed between the adult whorls. Apical whorls marked by two strong, subequal, revolving lirae, one near each suture, with a smaller, indistinct lira between them; primaries rapidly strengthening with the growth of the shell, the indistinct medial lira becoming less distinct, disappearing on the adolescent whorls; anterior carina a little larger than the posterior, or, more rarely, subequal to it; a small revolving lira appearing on the adult whorls just above and another just below the suture, never attaining a size comparable to that of the primaries. Incrementals distinct but not strongly marked, deeply arcuate, the maximum curvature attained just anterior to the prominent posterior carina, sharply recurved in front of the anterior carina. Parietal wash heavy, covering a wide area. Aperture not entire on any of the specimens observed.

Dimensions: Syntypes (as given by Palmer) (2866), height, 17 mm; greatest diameter, 15 mm; (2867), height, 10 mm; greatest diameter, 10 mm (just two adult whorls); (2870), height, 68 mm; greatest diameter, 22 mm (six adult whorls); (2871), height, 33 mm; greatest diameter, 12 mm (broken specimen, the apical portion measuring an additional 9 mm in height); (2875), height, 41 mm; greatest diameter, 14 mm (broken at apex and aperture). Figured specimen, height, 42 mm; greatest diameter, 14 mm (broken but slightly at the aperture).

Type material: Five syntypes in the collection of the Paleontological Research Institution, Ithaca, New York, nos. 2866, 2867, 2870, 2871, and 2875. An additional syntype figured by Mrs. Palmer, no. 2873, has been lost. Figured specimen, U. S. Nat. Mus. no. 495171.

Type locality: (nos. 2866 and 2867), Paleontological Research Institution sta. 724, Lisbon, Alabama River, Monroe County, Alabama. (Nos. 2870, 2871 and 2875), Paleontological Research Institution sta. 103, lower bed at the base of the bluff, on the Alabama River at Claiborne, Monroe County, Alabama. Figured specimen, U. S. G. S. sta. 6086, between the ferry and the boat landing, Claiborne. Claiborne group, Lisbon formation.

The subspecies *subrina* differs from *Turritella rina* in the absence of the basal carination and in the stronger development of the bicarinate sculpture. *Turritella cortezi* of the Claiborne of south Texas and northeast Mexico bears a superficial resemblance to *T. rina subrina*, for it, too, is without a basal carination and has a typically bicarinate sculpture strongly developed on both the apical and adult whorls. However, in the southern species the posterior lira is much stronger than the anterior, while in *subrina* the cords are subequal in strength, or the anterior is stronger than the posterior. The apical whorls of the two species are similar.

In the literature the prominently lirate Claiborne forms included by Mrs. Palmer in her *Turritella rina subrina* have been variously assigned to *Turritella bellifera*

Aldrich (Smith and Johnson, 1887, pp. 29, 30; Clark, 1891, pp. 63, 64; Aldrich, 1894, pp. 130, 233; Brantly, 1920, p. 161) and *Turritella eurynome* Whitfield (Aldrich, 1894, p. 233). The Claiborne forms, however, are quite distinct from these lower Wilcox species.

The subspecies *rina subrina* is found in association with *Turritella rina* in the eastern Gulf area and has also been recorded from East Texas in deposits that have yielded no material referable to *T. rina*, s.s. *Turritella rina subrina*, like *T. rina*, is confined to the Claiborne.

Distribution.—Claiborne group, McBean formation. SOUTH CAROLINA, *Orangeburg County:* U. S. G. S. sta. 2009, Caw Caw swamp, 2 miles west of Orangeburg courthouse.

Claiborne group, Lisbon formation. ALABAMA, *Monroe County:* U. S. G. S. stas. 2395, 3108, 6086, 12171, lowest bed at Claiborne Bluff, Alabama River; U. S. G. S. sta. 3105, Lisbon Bluff, Alabama River. *Clarke County:* U. S. G. S. sta. 12181, cliff on the Tombigbee River at Coffeeville.

Claiborne Group, Cook Mountain formation. TEXAS, *Houston County:* U. S. G. S. stas. 10735 and 10736, Alabama Crossing, Trinity River, 10 miles west of Porter's Springs. *Leon County:* U. S. G. S. sta. 14213, Two-mile Creek, first ford above Two-mile Negro Church, 3 to 4 miles south of Middleton.

TURRITELLA RINA CAROLINA Palmer

Turritella rina carolina PALMER, *1937*, Bull. Am. Paleontology, vol. 7, no. 32, p. 194, pl. 22, fig. 6.

Shell large, strongly sculptured; nepionic whorls unknown; immature whorls bicarinated with the lower carina the larger; at the same stage of development there is a fine, spiral rib just below the suture, one between the two primary ribs and one just above the suture; in maturity, the suture becomes excavated, the fine, spiral ribs enumerated increase in size until there are five large revolving ribs on the penultimate and body whorls; original carina slightly larger than the intermediate ribs; only fine spiral threads occur below the basal carina on the body whorl.

This species has the same basal pattern of sculpture as *T. rina* and *T. subrina*. It differs from *T. subrina* most conspicuously in the presence of the spiral rib developing between the two strong carinae. In *T. subrina* the mid-rib disappears. In *T. carolina* it increases in size.

Dimensions.—Height, 50 mm (incomplete); greatest diameter, 16 mm; apical angle, 15, holotype.

Holotype.—No. 2872, Paleontological Research Institution.

Occurrence.—Lower Claiborne: Locality 707 (about 3 miles west northwest of Orangeburg, S.C.). (Palmer, 1937.)

This subspecies is not represented in the collections of the National Museum.

TURRITELLA CORTEZI
Bowles, n. sp.
Plate 31, figures 11, 15

Shell fairly small, robust. Spire rather abruptly tapering. Whorls equidimensional and straight-sided in youth, wider than high and strongly carinate when adult. Apical whorls decorated with two prominent subequal revolving lirae, the posterior lira strengthening with the growth of the shell until, on the adult whorls, it is much more elevated than the anterior lira, forming a prominent subsutural carination; an indistinct secondary revolving lira appearing just in front of the suture on the adult whorls, but never becoming conspicuous. Incrementals indistinct, deeply arcuate, the maximum curvature falling just in front of the posterior carina, sharply recurved just behind the suture. Aperture not preserved entire.

Dimensions: Holotype, height, 30 mm; greatest diameter, 11 mm. Paratype, height, 22 mm; greatest diameter, 9 mm.

Type material: A holotype, U. S. Nat. Mus. no. 495172 and a paratype, U. S. Nat. Mus. no. 495173.

Type locality: U. S. G. S. sta. 13465, S. 44° W., 7200 meters from the church tower in Mier, Tamaulipas, Mexico. Claiborne group, Cook Mountain formation.

Turritella cortezi is one of the most distinctive of the Claiborne Turritellas. It most closely resembles *T. rina subrina* Palmer of the Lisbon formation of Alabama, but in the northern species the two revolving carinae are subequal in strength, and between the posterior primary carina and the posterior suture is a fairly strong secondary cord. In the Mexican and south Texan species, the subsutural carina is very prominent, the anterior less strongly developed, and the secondary cord inconspicuous or absent.

Turritella cortezi is among the most de-

pendable of the key fossils in the Claiborne of southern Texas and northern Mexico. Within a restricted stratigraphic range, it is extremely abundant. In the section of the Cook Mountain of Webb County, Texas, given by Lonsdale and Day (1937, p. 43), the 15-inch *Turritella* zone shown near the top of the Cook Mountain is the *Turritella cortezi* horizon. This horizon has been traced northward from Webb County through La Salle and southward through Zapata County and across the Rio Grande into Tamaulipas, where it bounds the Mier structure and has been followed for forty or more kilometers.

Distribution.—Claiborne group. Cook Mountain formation. TEXAS, *La Salle County:* U. S. G. S. sta. 14298, 2 miles southwest of Shelton Ranch house, 2½ miles (air line) southwest of Millet; U. S. G. S. sta. 14293, shingle below the Brinkley Ranch house, 4 miles (air line) northeast of Cotulla; U. S. G. S. sta. 14297, 1 mile southwest of windmill near Altita Ranch house, 3½ miles northeast of Cotulla; U. S. G. S. sta. 14296, southeast slope of Elm Creek, in road-side ditch on old Cotulla-Fowlerton road, 2.3 miles southeast of Cotulla; U. S. G. S. sta. 14295, one-half mile southeast of Rockwood, on Cotulla-LaMotta Ranch road; U. S. G. S. sta. 14294, 1.7 miles west of Encinal on Martin Ranch road in small pit on south side of the road from which surfacing material has been dug. *Zapata County:* U. S. G. S. sta. 14290, 1.1 miles northeast of Bench Mark 400, Zapata-Hebbronville road; U. S. G. S. stas. 14165, 14166, 14167, 14168, scarp on south side of Arroyo El Tigre both above and below the bridge on the Laredo-Roma highway; U. S. G. S. sta. 14291, hill side, one half mile east-northeast of the Fordyce Ranch house; U. S. G. S. sta. 14292, First bench above the Rio Grande south of Ramireño Ford, traceable from the bank of the Rio Grande to Ramireño. MEXICO. *Tamaulipas:* U. S. G. S. sta. 13465. S. 44°W. 7200 meters from church tower in Mier: U. S. G. S. sta. 13772, N. 44° W. 5780 meters from church tower in Mier; U. S. G. S. sta. 13806, S. 5° W. 330 meters from Rancho Mahuahuate; 650 meters N. 75° E. from Punta Nogales; U. S. G. S. sta. 13807, on west boundary of lot 6, 1240 meters due north from southwest corner; U. S. G. S. sta. 13957, in S. 30° W. brecha 1900 meters, S. 5° W. from Alto mesquital.

TURRITELLA WECHESENSIS
Bowles, n. sp.
Plate 31, figures 8, 14

Shell rather large, heavy. Spire high, gradually tapering. Whorls flat-sided in youth, slightly carinated when adult, separated by deeply impressed, linear sutures. Apical whorls marked by two prominent revolving lirae, one near the posterior suture and the other an equal distance from the anterior suture; a smaller revolving cord appearing between the two primaries and equidistant from them; an additional very small and indistinct lira appearing early between the posterior carina and the posterior suture; both the secondaries somewhat beaded at their intersections with the growth lines; entire surface of whorls marked by numerous very fine spiral threading; sculpture increasing in strength until about the tenth whorl, then gradually becoming less prominent with the growth of the shell, the two secondaries disappearing on the adult whorls; anterior primary developing into a distinct basal carination, sharper on the adolescent than on the adult whorls, but persisting throughout the shell development; posterior primary much reduced on the adult whorls until it is little more than a fine spiral thread on the body whorl, almost indistinguishable from the numerous fine revolving lines that cover the adult whorls. Incrementals distinct, very prominent, sharply cutting the spiral sculpture of the apical whorls and slightly beading the smaller revolving lirae; deeply arcuate, attaining their maximum curvature at about the posterior third of the whorl, very slightly reflexed at the anterior suture. Aperture not preserved entire.

Dimensions: Holotype (broken at the apex): height, 39.0 mm; greatest diameter, 10.0 mm. Paratype (broken at the aperture), height, 14.0 mm; greatest diameter, 4.0 mm.

Type material: A holotype (with 8 adolescent and adult whorls preserved). U. S. Nat. Mus. no. 497958; and a paratype (with 9 apical whorls preserved), U. S. Nat. Mus. no. 497959.

Type locality: U. S. G. S. sta. 9257, water

well at Percilla, Houston County, Texas. Claiborne group, Mt. Selman formation, Weches greensand member.

Turritella wechesensis differs from any other species of the Gulf Eocene in the obliteration of the sculpture on the adult whorls. At first glance the fully grown specimens seem to be simply worn, but on closer examination, the shell is found to be intact—even the finest of the revolving lines is preserved all the way to the body whorl. The early whorls somewhat resemble those of *Turritella rina*, especially after the decrease of the posterior carina sets in, but the ultimate extinction of the carina and the disappearance of the secondary ribbing readily distinguish this species.

Distribution.—Claiborne group, Mt. Selman formation. Weches greensand member. TEXAS, *Robertson County:* U. S. G. S. sta. 2050, Taylor's Well, 6 miles northwest of Wheelock. *Houston County:* U. S. G. S. sta. 9257, water well at Percilla.

TURRITELLA VAUGHANI
Bowles, n. sp.
Plate 32, figure 14

Turritella sp. COOKE, *1936, ex parte,* U. S. Geol. Survey Bull. 867, p. 64.

Shell very small. Spire high, extremely slender, gradually tapering. Whorls eleven in number in the incomplete holotype, flat-sided, separated by distinct but not deeply impressed sutures. Sculpture the same on all the whorls, consisting of two not very prominent revolving carinae, one near the anterior and one close to the posterior suture, the space between them much greater than that between either of them and the suture; medial space between revolving cords smooth, unmarked except for the indistinct growth lines. Incrementals recurved, the maximum retraction being just anterior to the posterior carina. Outer lip not preserved.

Dimensions: Holotype, height, 10.0 mm; greatest diameter, 2.0 mm. Holotype broken at aperture and apex.

Type material: A holotype, U. S. Nat. Mus. no. 497955.

Type locality: U. S. G. S. sta. 4580, Pooser's Hill, 5.1 miles north of Orangeburg, Orangeburg County, South Carolina. Claiborne Group, McBean formation.

Turritella vaughani is unique among the Turritellas of the Gulf and Atlantic Eocene, being more suggestive of the cingulate Jackson species *T. subtilis* Kellum, *T. martinensis* Dall and *T. rivurbana* Cooke than of the contemporary *T. rina* group. It is possible that the specimens here described are juveniles, but the sculpture is distinct from the apical sculpture of any other species, and since eleven whorls are present in the holotype, it is probable that more than the very youngest whorls are represented.

Turritella vaughani is represented in the collections of the National Museum only by the holotype and a single topotype.

TURRITELLA MARTINENSIS Dall
Plate 31, figure 10

Turritella indenta var. *martinensis* DALL, *1892,* Wagner Free Inst. Sci., Trans., vol. 3, pt. 2, pp. 308–309.
Turritella indenta Conrad. MCCALLIE, *1908,* Georgia Geol. Survey, Bull. 15, p. 357 Not *Turritella indenta* CONRAD, 1841.
Turritella martinensis Dall. COOKE, *1915,* U. S. Geol. Survey Prof. Paper 95, p. 111.

Shell large. Spire high, very gradually tapering. Whorls numerous, at least twice as wide as high, strongly concave, the constriction being situated medially on the whorl; sharply delimited by the linear, distinct, and not deeply impressed sutures, but not constricted at the sutures. Extreme apical whorls unknown; earliest whorls preserved exhibiting two strong revolving cords, one near the anterior and one close to the posterior suture, the space between sculptured by finer, secondary lines; two accessory revolving lirae appearing on the third or fourth whorl, one just in front of the posterior primary and one just behind the anterior, gradually increasing in size with the growth of the shell until on the adult whorls the sculpture consists of four subequal prominent lirae arranged in pairs with a deeply excavated medial portion between, this intervening space marked only by indistinct threads. Incrementals strong, deeply arcuate, the maximum retraction attained about medially or a little behind the median of the whorl, slightly recurved just behind the suture; cutting the revolving threads and giving them a strongly beaded appearance. Entire aperture unknown.

Dimensions: Lectotype, height, 35.0 mm;

greatest diameter, 12.5 mm. The lectotype is broken both at the aperture and apex.

Type locality: Quarry at Martin station, Hernando County, Florida. Jackson group, Ocala limestone.

Type material: U. S. Nat. Mus. no. 498390, consisting of a number of incomplete specimens still imbedded in the porous matrix. The most perfect of these has been selected as the lectotype.

Turritella martinensis is most closely related to *T. subtilis* and *T. rivurbana* of the Jackson, but it differs from these two species in the double carination of the adult whorls and in its larger size. Like the other cingulate Turritellas of the Jackson, *T. martinensis* is probably derived from *T. vaughani* of the Claiborne of South Carolina.

The differences between the topotypes and the specimens from the Barnwell sand are possibly of systematic importance. The Barnwell sand forms seem to be less slender and the sculpture pattern is elaborated by the introduction of two additional lirae, the one behind the anterior lira, the other behind the posterior. The same tendency toward the development of additional lirae is shown, however, in one of the juveniles from Martin Station, and the pattern is not uniform in the Barnwell individuals. Some of the variants approach very closely to *T. subtilis* Kellum from the Castle Hayne marl. The material is not very well preserved and is difficult to separate from the matrix.

Distribution.—Jackson group, Barnwell formation. GEORGIA, *Burke County:* ? U. S. G. S. sta. 3663, 9 miles east of Waynesboro; ? U. S. G. S. sta. 3664, Steiner's Branch, 5 miles south of Waynesboro; ? U. S. G. S. sta. 3935, roadside gully, near Rocky Creek, Louisville Road, 5 miles west of Waynesboro. *Jefferson County:* ? U. S. G. S. stas. 5247 and 7428, Old Town road, east side of Boiling Spring Creek, 7.5 miles southeast of Louisville; ? U. S. G. S. sta. 7713, roadside, 6.1 miles from Louisville on the road to Sandersville; ? U. S. G. S. sta. 7714, Old Town, 8.4 miles southeast of Louisville. *Twiggs County:* ? U. S. G. S. sta. 7426, 2 miles east of Dry Branch. *Bibb County:* ? U. S. G. S. sta. 7696, Brown's Mountain, near Bond's store, 9 miles south of Macon.

Jackson group, Ocala limestone. GEORGIA, *Miller County:* ? U. S. G. S. sta. 8336, 3 miles west of Colquitt. FLORIDA, *Hernando County:* U. S. Nat. Mus. nos. 112444 and 112589, Martin's Station.

TURRITELLA SUBTILIS Kellum

Turritella subtilis KELLUM, *1926*, U. S. Geol. Survey, Prof. Paper 143, p. 27, pl. 5, fig. 5. NOT Stephenson, *1927* (= *Turritella kellumi* Stephenson).

Shell coiled, slender, tapering; suture simple, distinct, not deeply impressed; sculpture delicate; whorls divided into three subequal parts by two low, sharp spiral threads, between which is a third, less prominent thread; lower whorls have, at base bordering the suture, another spiral thread, which becomes obsolete in the higher whorls; indistinct axial growth lines. Total number of whorls and shape of aperture unknown. Length of fragment of 10 whorls, 24 mm.

The type specimen of this species is a cast of the exterior of the shell, preserving the most delicate sculpture.

Locality: Wilmington, New Hanover County, N. C.

Geologic horizon: Castle Hayne marl, of Jackson Eocene age. (Kellum, 1926.)

Turritella subtilis is known only from the type locality. It is apparently closely related to *T. martinensis* Dall of the Ocala limestone of Georgia and Florida and the allied specimens from the Barnwell sand of northern Georgia and to *T. rivurbana* of the Moodys marl of Mississippi. All three species are characterized by the cingulate sculpture of the apical whorls. *T. subtilis*, however, is more slender and gradually tapering than the other cingulate Jackson species, and the whorls are marked by more prominent secondary lirae.

TURRITELLA RIVURBANA Cooke

Turritella rivurbana COOKE, *1926*, Washington Acad. Sci., Jour., vol. 16, no. 5, p. 136, fig. 10.

Shell small for the genus. Spire high?, gently tapering. Whorls concave in profile, carinated anteriorly and posteriorly with the maximum constriction of the whorls reached a little behind the median. Sutures linear but distinct, deeply impressed but not channelled, the whorl somewhat undercut basally and sharply constricted immediately behind the suture. Apical whorls not preserved; adolescent and adult whorls marked by two strong revolving lirae, which are set far apart, one very near the anterior and one close to the posterior suture, the anterior lira being the stronger and dis-

tinctly carinating the whorl basally; a smaller revolving rib present between the posterior carina and the suture, becoming relatively less prominent with the shell development, but still visible on the youngest whorl preserved; on the earliest preserved whorls two additional accessory lines appear symmetrically placed between the two primary carinae, very fine and narrow, becoming even more indistinct with the gowth of the shell until on the last whorl preserved they are almost invisible; entire surface of whorl sculptured by fine, microscopic revolving lines, not visible to the naked eye. Incrementals distinct but not prominent, strongly arcuate, the deepest part of the sinus falling a little behind the median of the whorl, an additional very slight reflexion apparent on the under side of the anterior carina. Aperture not preserved.

Dimensions: Holotype, height, 17.5 mm; greatest diameter, 8.0 mm. The holotype is an incomplete individual, broken both at the tip and the aperture.

Type material: A holotype, U. S. Nat. Mus. no. 353946.

Type locality: U. S. G. S. sta. 6466, Town Creek, 200 yards south of the intersection of Rankin and South State Streets, Jackson, Hinds County, Mississippi. Jackson group, Moodys marl.[3]

Turritella rivurbana is not common in any of its occurrences. The bicarinate adult whorls distinguish this species from the multilirate *T. perdita* and *T. alveata* of the underlying Moodys marl. There is a general resemblance between *T. rivurbana* and the other bilirate Jackson species, *T. subtilis* Kellum and *T. martinensis* Dall, but its small size and lack of strong secondary sculpture on the adult whorls readily distinguish it. *T. rivurbana* may have been derived from *T. vaughani*, the cingulate species of the McBean formation of South Carolina.

Distribution.—Jackson group, Moodys marl. MISSISSIPPI, *Hinds County:* U. S. G. S. sta. 6466, Town Creek, 200 yards south of the intersection of Rankin and South State Streets, Jackson; U. S. G. S. sta. 6467, Town Creek, south of the corner of Rankin and South State Streets. *Yazoo County:* U. S. G. S. sta. 7674, Roadside on hill at Sims station, Yazoo & Mississippi R. R., 10 miles north of Yazoo City and 2 miles south of Eden; U. S. G. S. sta. 10118, Near the head of a ravine about three-fourths of a mile southeast of Free Run on the line between SE¼ sec. 26 and SW ¼ sec. 25, T. 13 N., R. 1 W., about 10 miles northeast of Yazoo City.

[3] Originally referred to the Yazoo clay. Cooke now places it in the Moodys marl.

III. BICOSTATE GROUP

TURRITELLA TENNESSEENSIS Gabb

Plate 32, figure 12

Turritella tennesseensis GABB, *1860*, Acad. Nat. Sci. Philadelphia, Jour., 2nd ser., vol. 4, p. 392, pl. 68, fig. 13.—HARRIS, *1896*, Bull. Am. Paleontology, vol. 1, no. 4, p. 108, pl. 11, fig. 5.—ALDRICH, *1921*, Bull. Am. Paleontology, vol. 9, no. 37, p. 25.

Turritella sp. LOWE, *1933*, Mississippi Geol. Survey, Bull. 25, p. 9.

Turritella mortoni Conrad. LOWE, *1933 ex parte*, Geol. Survey Mississippi, Bull. 25, p. 10 (stations 6496 and 6497 only).

Spire high, gently tapering. Whorls numerous, straight-sided or slightly concave in profile, the adult whorls usually more concave than the apical. Sutures linear, shallow, indistinct. Apical whorls with two strong revolving cords placed close together on the medial portion of the whorl, usually closer to each other than to the sutures; intercalaries arising early on the whorls, the first two appearing on the fourth or fifth whorl, one just above and one just below the suture; additional intercalaries gradually appearing so that the spirals are very numerous on the last few whorls. Primary cords of the apical whorls persistent but relatively weaker on the adult whorls, the chief character of the later whorls being a marked basal carination slightly overhanging the suture. Growth lines distinct and sharply flexed well behind the median of the whorl, reflexed again and meeting the anterior suture a little behind their intersection with the posterior suture. No perfect aperture observed.

Dimensions: Holotype "Length (restored)? 1.2 in.? width of body whorl, one inch from apex, .35 in." (Gabb, 1860). Figured specimen, height, 25.5 mm; greatest diameter, 9.5 mm.

Type material: According to Harris (1896, p. 108) the type of this species is in the collection of Professor Safford at Vanderbilt University, but they have no record

of it in Nashville, nor is it in the Gabb collection of the Philadelphia Academy of Natural Sciences. Figured specimen, U. S. Nat. Mus. no. 497989.

Type locality: "Hardeman County, Tenn., marls of the Ripley Group" (Gabb, 1860). Figured specimen, U. S. G. S. sta. 6495, 200 feet east of milepost 481, 1½ miles east of Middleton, Hardman County, Tennessee. Midway group, Clayton formation.

Turritella tennesseensis most closely resembles *T. alabamiensis* Whitfield of the Alabama Midway. It differs from this species, however, in the strongly concave adult whorls, and in the consistently bicarinate apical sculpture. Three revolving cords, rather than two, are present on the apical whorls of *T. alabamiensis*.

Turritella tennesseensis may represent the ancestral type of such bicostate species as the *T. lisbonensis* and *T. dutexata* of the Claiborne, but there are no known connecting forms, and the relationships are obscure.

Harris has recorded *T. tennesseensis* from the Midway (Clayton) limestone of the Chattahoochee River, Georgia, but there is no similar material from Georgia in the collections of the National Museum. I have found the species only in collections from the Clayton limestone of Tennessee and Mississippi.

Distribution.—Midway group, Clayton formation. MISSISSIPPI, *Tippah County:* U. S. G. S. sta. 5586, ravine just north of the Booneville road, 3 miles northeast of Ripley; U. S. G. S. sta. 6496, bluff on small stream about 1½ miles south of Ripley; U. S. G. S. sta. 6497, bluff on south side of Owl Creek, 2¾ miles northeast of Ripley and about ¼ mile east of the Ripley-Troy road. TENNESSEE, *Hardeman County:* U. S. G. S. sta. 6091, milepost 481, east of Middleton; U. S. G. S. sta. 6495, 200 feet east of milepost 481, 1½ miles east of Middleton.

TURRITELLA DUTEXATA Harris
Plate 31, figure 2

Turritella dutexata HARRIS, *1895*, Acad. Nat. Sci. Philadelphia, Proc. for 1895, p. 82, pl. 9, fig. 8.—KENNEDY, *1895*, Acad. Nat. Sci. Philadelphia, Proc. for 1895, p. 114.—PALMER, *1937*, Bull. Am. Paleontology, vol. 7, no. 32, pp. 188, 189, 198, pl. 26, figs. 1–4, 8, 9.
Turritella dutexana VAUGHAN, 1895, Am. Geologist, vol. 15, pp. 213, 217 (typographical error).
Turritella femina STENZEL, *1931*. Univ. Texas, Bull. 3101, pp. 87, 89, 107, pl. 6, fig. 14.—PLUMMER, *1933*, Univ. Texas, Bull. 3232, pp. 647, 815.—PALMER, *1937*, Bull. Am. Paleontology, vol. 7, no. 32, p. 203, pl. 26, fig. 5.

Spire high, slender, gently tapering. Whorls rounded, inflated, slightly constricted at the linear but distinctly impressed sutures. Apical whorls marked by two prominent revolving lirae, the anterior stronger than the posterior; a secondary rib appearing on the third or fourth whorl, smaller than and posterior to the two prominent primary lirae; more secondary ribs gradually added until on the adult whorls there are three prominent secondary ribs between the posterior primary and the suture, a smaller rib between the two primary lirae and one or two secondary ribs between the anterior primary lira and the anterior suture; the characteristic bicarination of the whorls persisting, but the increase in the size of the secondary lirae somewhat obscuring it in larger specimens; adult whorls covered by very fine revolving lines on the lectotype. Incrementals strongly sinuous, the maximum retraction occurring just behind the posterior primary carina. Base of body whorl cancellated by the intersection of the growth lines and the fine spiral striations. Aperture not preserved complete.

Dimensions: Lectotype, height, 33.0 mm; greatest diameter, 10.0 mm.

Type material: The holotype of *T. dutexata* was formerly in the Singley collection of the Department of Geology, University of Texas, Austin, Texas, but it has been lost. The lectotype, no. 497952, was selected from a collection in the National Museum, identified by Harris and mentioned by him in his original description of the species. The holotype of *T. femina* Stenzel is at the Bureau of Economic Geology, Austin, Texas.

Type locality: No type locality was given by Harris in his original description of the species. The lectotype is from U. S. G. S. sta. 2050, 5 miles southeast of Franklin, Robertson County, Texas. The holotype of *T. femina* Stenzel is from Buck McBride's 134-acre tract, José Maria Viesca Survey, Robertson County, Texas. Claiborne group, Mt. Selman formation, Weches greensand member.

The inflated whorls of *Turritella dutexata*

bear a superficial resemblance to those of the Jackson species *Turritella arenicola* Conrad, but in the younger species the nepionic whorls are characteristically unicarinate. The most closely related species is apparently *Turritella lisbonensis* of the Claiborne of the Eastern Gulf province, although this species has a straight-sided spire that is more gradually tapering.

It is unfortunate that the type of *Turritella dutexata* has been lost, as the original figure does not portray the species well. The original description, however, is adequate, and Harris' material in the National Museum matches this description to an extent that makes the selection of a lectotype imperative.

Stenzel's species *Turritella femina* did not become valid, as Mrs. Palmer has pointed out, until the publication of Plummer's report in 1933, where a few descriptive remarks were made in a key to the Eocene species of *Turritella*. Dr. Plummer's description of the sculpture applies only to the adult whorls, and for this reason is misleading. He states that the sculpture consists of "7 fine spirals of equal size." There are seven subequal spirals on the most adult whorls of some of the largest specimens, but the younger whorls show the characteristic bicarination with the five rapidly strengthening secondaries. Doctor Stenzel's figure shows this sculpture very well.

Distribution.—Claiborne group, Lisbon formation. ALABAMA, *Monroe County:* U. S. G. S. sta. 5511, one mile below Lisbon Landing, Alabama River. MISSISSIPPI, *Clarke County:* U. S. G. S. sta. 338, 3–5 miles east of Shubuta; U. S. G. S. stas. 131, 2616, Wautubbee Hills, 4 miles west of Enterprise; U. S. G. S. sta. 2622, old Enterprise road, Johnson's farm, 8 miles south of Hickory and 12 miles northwest of Enterprise; U. S. G. S. sta. 2621, Rose Hill road, 8 miles west of Enterprise; U. S. G. S. sta. 2623, Wautubbee Hills, Johns farm, south of creek and 9½ miles south of Hickory; U. S. G. S. sta. 6480, abandoned road 3 or 4 miles south of Enterprise, about ¼ mile southeast of the old Kemper homestead. *Newton County:* U. S. G. S. sta. 2624, old Enterprise road, going down the hill to the Pottoxchitto Swamp, 2 miles southeast of Hickory; U. S. G. S. sta. 2625, Paulding Road (General Jackson's road from Nashville to New Orleans), 1 mile south of Hickory; U. S. G. S. sta. 14058, railroad cut at Indian Mound, 3¼ miles east of Newton.

Claiborne group, St. Maurice formation. LOUISIANA, *Bienville Parish:* U. S. G. S. sta. 2033, Holston's well, 5 miles southeast of Gibbsland; U. S. G. S. sta. 2911, Mt. Lebanon; U. S. G. S. sta. 2037, well at "Rabun's place." sec. 19, T. 17. R. 5 W. *Claiborne Parish:* U. S. G. S. sta. 2038, Pittman's Mill, SW ¼ SE ¼ Sec. 19, T. 19, R. 7 W. *Winn Parish:* U. S. G. S. sta. 2005, mouth of Saline Bayou, St. Maurice; U. S. G. S. sta. 2919, 10 miles northwest of Winnfield.

Claiborne group, Mt. Selman formation, Weches greensand member. TEXAS, *Robertson County:* U. S. G. S. sta. 2050, Taylor's well, 5 miles southeast of Franklin and 6 miles northwest of Wheelock. *Anderson County:* U. S. G. S. sta. 10852, 1½ miles southeast of Palestine on the Boston road. *Leon County:* U. S. G. S. sta. 13266, ½ mile east of Robins on the Centerville road.

TURRITELLA LISBONENSIS Bowles, n. sp.
Plate 31, figures 1, 3

Turritella nasuta Gabb. PALMER, *1937, ex parte,* Bull. Am. Paleontology, vol. 7, no. 32, p. 200, pl. 25, figs. 3, 9 (only).

Shell large. Spire high, gently tapering in the adult stage, more abruptly tapering in youth, the sharp change in the spire profile appearing at about the eighth or ninth whorl. Whorls wider than high, especially in the young stages, slightly rounded, separated by indistinct linear sutures. Apical whorls marked by two prominent, sharp, revolving lirae set very close together and situated much nearer the anterior than the posterior suture; a smaller secondary thread appearing on the third whorl between the primary cords and the posterior suture, remaining small throughout the growth of the shell; an additional fine revolving line appearing between the two primary lirae on the ninth whorl, and persisting through the adult stages; area between the anterior primary cords and the suture slightly constricted toward the suture, and marked only by fine revolving lines. Incrementals slightly arcuate, the maximum of the curvature being attained at about the posterior third of the whorl, very slightly recurved just above

the suture. Aperture not well preserved; apparently rounded. Outer lip badly broken.

Dimensions: Holotype, height, 39.5 mm greatest diameter, 8.5 mm.

Type material: A holotype, U. S. Nat. Mus. no. 498009.

Type locality: U. S. G. S. sta. 3105, Lisbon Bluff, Alabama River, Monroe County, Alabama. Claiborne group, Lisbon formation.

Turritella lisbonensis has commonly been grouped with *T. nasuta felli*, the Lisbon member of the *T. nasuta* group. It probably only resembles this group superficially, however, as the apical sculpture is strikingly different, *T. lisbonensis* bearing only two nepionic primaries, while *T. nasuta* and its subspecies are characterized by three. The abrupt decrease in the apical angle of the spire in adolescence is sufficiently diagnostic to make easy the identification of even poorly preserved fragments. *Turritella arenicola* Conrad of the Jackson is the only other Eocene species that exhibits such a striking change in the angle of the spire. The large size, multistriate adult ribs, and but slightly rounded whorls are sufficient to distinguish this species from the closely allied *Turritella dutexata* Harris.

Turritella lisbonensis is confined to the Claiborne of the eastern Gulf region. It is widespread in Alabama, Georgia and South Carolina, and sparingly represented in correlative beds in Mississippi.

Distribution.—Claiborne group, McBean formation. SOUTH CAROLINA, *Aiken County:* U. S. G. S. sta. 4603, Hixon Bridge, Tinker's Creek, public road 200 feet east of bridge, 12½ miles west of Williston. *Lexington, County:* U. S. G. S. sta. 7731, property of Eugene Senn, north of Kennerly road, Lexington-Calhoun county line, ¼ mile north of house, 7 miles east of Swansea; U. S. G. S. sta. 7732, south of old Bethel Church and east of Lexington-Orangeburg road, about 2 miles southeast of Edmund. *Orangeburg County:* U. S. G. S. sta. 7816, Stroman's Mill, 5 miles southeast of Springfield, U. S. G. S. sta. 7722, Columbia road, south of Early Branch, about 5 miles north of Orangeburg; U. S. G. S. sta. 2009, Caw Caw Swamp, 2 miles west of Orangeburg; U. S. G. S. sta. 4580, Pooser's Hill, 5.1 miles north of Orangeburg Courthouse, U. S. G. S. sta. 2021, At old brickyard in Orangeburg. GEORGIA, *Burke County:* U. S. G. S. sta. 5296, Sloan's Scarp, McBean Creek; U. S. G. S. sta. 3288, McBean Creek, on land of Henry Byn.

Claiborne group, Lisbon formation. ALABAMA, *Clarke County:* U. S. G. S. sta. 6157, between the Alabama and Tombigbee Rivers, 1 mile southwest of Rockville and 8½ miles southeast of Jackson. *Conecuh County:* U. S. G. S. sta. 6737, east side of the Sepulga River on land of J. G. Robinson, sec. 13, T. 4 N., R. 13 E. *Monroe County:* U. S. G. S. stas. 2391, 2584, 2668, 3105, 5511, and 6086, Lisbon Bluff, Alabama River; U. S. G. S. sta. 13433, Lisbon Bluff, Alabama River, bed 4 of the Cooke section; U. S. G. S. stas. 13431 and 14215, Lisbon Bluff, Alabama River, bed 7 of the Cooke section. MISSISSIPPI, *Clarke County:* U. S. G. S. stas. 131, 2616, 3092, and 6479, 1 mile north of Wautubbee Station on the N. O. & N. E. R. R., just north of milepost 20, south of Meridian; U. S. G. S. sta. 2621, in wash of Rose Hill road, 8 miles west of Enterprise; U. S. G. S. sta. 2622, in wash of old Enterprise road, at residence of Mr. J. Harrison Johnson, 8 miles south of Hickory and 12 miles northwest of Enterprise; U. S. G. S. sta. 2623, in a washed off place in Mr. J. H. Johnson's farm, south of the creek and about 9½ miles south of Hickory; U. S. G. S. sta. 14218, south bank of the Chickasawhay River at bridge on route 45, 1 mile south of Quitman; U. S. G. S. sta. 14220, McLeod's Mill, Suwamlovey Creek, 5 miles westsouthwest of Quitman; U. S. G. S. sta. 14229, bluff on old bridge site on southwest bank of the Chickasawhay River, DeSoto; *Newton County:* U. S. G. S. sta. 2624, in wash of old Enterprise road, going down to the Pottoxchitto swamp, 2 miles southeast of Hickory; U. S. G. S. sta. 14058, railroad cut, Indian mound, about 3¼ miles east of Newton.

Claiborne group, Cook Mountain formation. TEXAS, *Atascosa County:* U. S. G. S. sta. 13231, one mile east of Jourdanton on the Pleasanton road. *Bastrop County:* U. S. G. S. sta. 5284, near the county line in the southwest part of Bastrop County. *Brazos County:* U. S. G. S. sta. 14210, 9.8 miles from main corner of Bryan on Highway 21, at crossing of Little Brazos River, 50 to

300 feet upstream from bridge; basal part of section; U. S. G. S. sta. 5473, Moseley's Ferry. *Leon County:* U. S. G. S. sta. 14213, Two-Mile Creek, first ford above Two-Mile Negro church, 3–4 miles south of Middleton.

IV. TRICOSTATE GROUP

TURRITELLA NASUTA Gabb

Plate 32, figures 5, 6

Turritella nasuta GABB, *1860*, Acad. Nat. Sci. Philadelphia, Jour., 2nd ser., vol. 4, p. 385, pl. 67, fig. 42.—DANA, *1895*, Manual of geology, 4th edition, fig. 1484.—TROWBRIDGE, *1932*, U. S. Geol. Survey, Bull. 837, pl. 42, fig. 7.—PALMER, *1937* (*ex parte*), Bull. Am. Paleontology, vol. 7, no. 32, p. 200, pl. 83, fig. 5 (Not pl. 25, figs. 1–3, 5, 8, 9).

Shell small. Spire high, slender, very gradually tapering. Whorls numerous, straight-sided, slightly wider than high. Sutures linear but distinct, the whorls sharply constricted at the sutures in the young stages, less distinctly constricted when adult. Apical whorls marked by three distinct revolving lirae, equidistant from each other and from the sutures, the two anterior more prominent than the posterior, the posterior, however, gradually increasing in size until it equals the other two in strength at about the eighth whorl; a fine secondary lira appearing on the ninth whorl between the posterior primary and the suture and another between the anterior primary and the suture, both rapidly increasing in size, but never quite attaining the prominence of the primary cords; fine spiral threading appearing on the tenth and eleventh whorls between the primary cords, usually two between each of the primaries. Incrementals distinct but not prominent, deeply bent at about the posterior third of the whorl, slightly recurved just above the suture. Aperture not preserved entire.

Dimensions: (as given by Gabb) length, 1 inch; width of body whorl, 0.2 inch; length of mouth, 0.15 inch. Figured specimen, height, 26.0 mm; greatest diameter, 4.5 mm.

Type material: a lectotype and five paratypes in the Academy of Natural Sciences of Philadelphia, no. 13293. Figured specimen, U. S. Nat. Mus. no. 498004.

Type locality: (according to Gabb) "Caldwell Co., Texas and Wheelock" (Gabb, 1860). Figured specimen, U. S. G. S. sta. 14210, Little Brazos River, 9.1 miles from the main corner of Bryan on highway 21, 50 to 300 feet above bridge, Brazos County, Texas. Claiborne group, Cook Mountain formation.

The name "*Turritella nasuta*" has been used widely in the literature, but more as a group designation than as a specific concept. The group is extremely well marked, the high, narrow, very gently tapering spire in conjunction with the typical tricostate sculpture of the apical whorls readily distinguishing *Turritella nasuta* and its subspecies from the other Eocene Turritellidae. The subspecies *felli* from the Lisbon of Alabama and the McBean of Georgia, *smithvillensis* from the Weches, and *houstonia* from the upper Cook Mountain of Texas differ but slightly from the typical *T. nasuta* of the Cook Mountain.

As here restricted, *Turritella nasuta* Gabb is confined to the Cook Mountain formation and its equivalents in Louisiana, Texas and northern Mexico. It is an extremely abundant species throughout its range, and, at least in south Texas and north Mexico, is an excellent horizon marker. The section given by Lonsdale and Day (1937, p. 43) for the Webb County middle Eocene, is, in a generalized way, applicable to the whole area south of La Salle County and across the Rio Grande into Tamaulipas and northern Nuevo León. In this southern part of its range *Turritella nasuta* is characteristic of the middle part of the Cook Mountain section, below the stratigraphically thin but geographically persistent *Turritella cortezi* horizon. *T. nasuta* seems to have less stratigraphic significance north of La Salle County. Well-characterized individuals specifically identical with topotypes have been recovered from the so-called "Derby zone" of basal Cook Mountain age surrounding the Pearsall structure in Frio County as well as from higher Cook Mountain strata in east Texas and Louisiana. Vaughan (1895, p. 213; 1986, p. 43) has recorded the species from several Louisiana localities. Dumble (1894, 1915, 1920) lists *Turritella nasuta* from numerous localities in Texas and northern Mexico and other Texas records have been made by Kennedy (1895) Trowbridge (1923) and Deussen (1916).

The citations of *Turritella nasuta* by Stephenson and Veatch (1911, 1915) in their Georgia reports are references to the sub-species *felli*, herein described.

Distribution.—Claiborne group, Cook Mountain formation. LOUISIANA, *Webster Parish:* U. S. G. S. sta. 13059, 2 miles southeast of Minden. TEXAS, *Anderson County:* U. S. G. S. sta. 13265, 11.5 miles north of Grapeland on the Palestine road. *Atascosa County:* U. S. G. S. sta. 13282, Northwest road south of railroad track in Jourdanton, 1.1 miles from the highway. *Brazos County:* U. S. G. S. sta. 14209, 9.8 miles from main corner Bryan on Highway 21, 50 to 300 feet upstream from highway crossing, Little Brazos River; upper part of section; U. S. G. S. sta. 14210, same locality, lower part of section. *Frio County:* U. S. G. S. sta. 13347, high hill about 7 miles west-northwest of Dilley; U. S. G. S. sta. 13363, Catarina Hill north side, upper bed, Gilman Ranch, about 6 miles northwest of Pearsall; U. S. G. S. sta. 13364, 1 mile west of Catarina Hill on the Gilman Ranch, 6 miles northwest of Pearsall; U. S. G. S. sta. 14001, one hundred yards north of underpass on I & G. N. R. R., 1.2 miles north of Derby on the Laredo-San Antonio road. *Houston County:* U. S. G. S. sta. 9257. José Procela League, from water well dug at village gin in 1916, Percilla. *La Salle County:* U. S. G. S. sta. 13373, old Cotulla Road, 2.1 miles from its intersection with the Cotulla-Tilden road, 4.5 miles southeast of Cotulla. *Robertson County:* U. S. G. S. stas. 10343, 10375, 13268 and 14274, Moseley's Ferry, Stone City, west bank of the Brazos River; U. S. G. S. sta. 13043, Cedar Creek, ¼ mile upstream on the Wheelock-Normangee road. *Sabine County:* U. S. G. S. sta. 11104, west side of the Sabine River, 10 to 20 feet below the typical Cook Mountain; U. S. G. S. sta. 11105, about 10 feet below the typical Cook Mountain, 2½ miles south of Low's Creek, Sabine River, on north side of John Moore Survey, ½ mile east of intersection of Survey line and Sabine River. *Wilson County:* U. S. G. S. sta. 6141, Bluff on San Antonio River, 4 miles south southeast of Floresville. *Webb County:* U. S. G. S. sta. 8771, 4 miles southeast from Laredo; U. S. G. S. sta. 9166, 5 miles north of Laredo. *Zapata County:* U. S. G. S. sta. 13168, Arroyo Valeño; below bridge on Zapata-Roma road; U. S. G. S. sta. 13172, Concretionary bed at head of tributary about 2 miles northwest of Arroyo Valeño; U. S. G. S. sta. 13193, north bank of Arroyo El Burro, about ½ mile above highway, San Ygnacio Quadrangle; U. S. G. S. sta. 13227, Arroyo San Bartolo, about 200 feet below Laredo Highway crossing.

TURRITELLA NASUTA SMITHVILLENSIS Bowles, n. subsp.

Plate 32, figures 7, 13

Turritella nasuta Gabb. PALMER, *1937, ex parte*, Bull. Am. Paleontology, vol. 7, no. 32, p. 200, pl. 25, figs. 5, 6 (Not pl. 25, figs. 1, 2, 3, 8, 9, 10, pl. 83, fig. 5).

Shell small. Spire high, slender, very gradually tapering. Whorls very numerous, rounded, slightly wider than high when young, becoming almost equidimensional when adult. Sutures distinct, linear, deeply impressed, sharply constricting the whorls throughout the growth of the shell. Apical whorls marked by three revolving lirae, the medial slightly closer to the anterior than to the posterior; posterior lira slightly smaller than the two anterior on the earliest whorls, rapidly increasing in size until the three are subequal in strength on the adolescent and adult whorls; a fine revolving lira appearing between the primaries and the posterior suture on the sixth whorl; lirae appearing also between the primaries and between the anterior primary and the anterior suture on the tenth whorl; secondaries rapidly increasing in size with the growth of the shell until the adult whorls are marked by seven subequal revolving liration with five or more finer lines irregularly placed between them; very fine spiral threading covering the entire surface of the post-nuclear whorls. Incrementals distinct, strongly marked, deeply arcuate, the maximum retraction occurring just behind the median of the whorl, slightly recurved a little above the suture. Aperture slightly higher than wide. Outer lip fragile, not preserved entire. Parietal wash small, thin, indistinct.

Dimensions: Holotype (broken slightly at the apex), height, 22.8 mm; greatest diameter, 4.5 mm. Paratype (broken at

the aperture), height, 12.2 mm; greatest diameter, 2.2 mm.

Type material: A holotype (nine adult whorls preserved), U. S. Nat. Mus. no. 497998, and a paratype (fifteen early whorls preserved), U. S. Nat. Mus. no. 497999.

Type locality: Holotype, U. S. G. S. sta. 10386 and paratype U. S. G. S. sta. 6088, Smithville, Bastrop County, Colorado River, Texas. Claiborne group, Mt. Selman formation, Weches member.

The subspecies *smithvillensis* may be distinguished from *Turritella nasuta*, s. s., by its more rounded whorls and more deeply incised sutures. It has been recovered only from deposits of Weches age in Texas, where it is the sole representative of the *Turritella nasuta* stock. It is nowhere very abundant, but it is not rare at Smithville.

Distribution.—Claiborne group, Mt. Selman formation. Weches greensand member. TEXAS, *Anderson County:* U. S. G. S. sta. 10604, small creek, northeast of lignite mine on property of Palestine salt works, Palestine. *Bastrop County:* U. S. G. S. stas. 6088 and 10386, middle greensand bed above bridge over Colorado River at Smithville.

TURRITELLA NASUTA FELLI
Bowles, n. subsp.
Plate 32, figures 4, 8

Turritalla nasuta Gabb. PALMER, *1937, ex parte,* Bull. Am. Paleontology, vol. 7, no. 32, p. 200, pl. 25, figs. 1, 2, 8 (Not pl. 25, figs. 3, 5, 6, 9, 10; pl. 83, fig. 5).

Shell large. Spire high, narrow, very gradually tapering. Whorls numerous, wider than high, very slightly rounded, not sharply constricted at the sutures. Sutures linear but distinct, not deeply impressed. Earliest whorls unknown; first apical whorl preserved exhibiting three subequal revolving lirae, the middle one closer to the anterior than to the posterior lira, the distance between the posterior lira and the suture less than that between the anterior lira and the suture; anterior primary becoming relatively more prominent in adolescence; a smaller, secondary cord appearing between the two posterior primaries early in adolescence, an additional secondary arising between the two anterior primaries a few whorls later, and a third subordinate lira appearing between the posterior primary and the suture late in adolescence; the two posterior secondaries rapidly increasing in prominence until on the adult whorls they are equal in strength to the three primaries, the secondary between the two anterior primaries remaining small; a variable number of additional fine, revolving lines added on the adult whorls between the prominent cords; adult whorls typically marked by five strong and four weak revolving lirae, some specimens exhibiting five to eight strong revolving lines. Incrementals prominent, deeply flexed at about the median of the whorl and slightly reflexed at the anterior suture. Aperture not preserved complete.

Dimensions: Holotype, height, 43.0 mm; greatest diameter, 7.5 mm. Figured specimen, height, 33.0 mm; greatest diameter, 6.5 mm.

Type material: A holotype (with 13 adult whorls preserved), U. S. Nat. Mus. no. 498005. A figured specimen (with 15 early whorls preserved), U. S. Nat. Mus. no. 498006.

Type locality: U. S. G. S. sta. 13433, Lisbon Bluff, Alabama River, Monroe County, Alabama, bed 4 of the Cooke (1926, p. 270) section. The figured specimen is from U. S. G. S. sta. 13431, Lisbon Bluff, bed 7 of the Cooke section. Claiborne group. Lisbon formation.

Turritella nasuta felli differs from typical *nasuta* of the western Gulf province in its larger size and its much more prominent adult sculpture. The subspecies is restricted to the Claiborne of the eastern Gulf region, being found only in the Lisbon formation of Alabama and the correlative McBean formation of Georgia.

The citations of *Turritella nasuta* by Stephenson and Veatch (1911, 1915) in their Georgia reports are references to this species.

Mrs. Palmer (1937, p. 201) called attention to the great variety of forms included under Gabb's original name in the literature, and she figured a number of these variants, some of which are herein described.

I take great pleasure in naming this subspecies in honor of George Fell of Claiborne, Alabama, who gave me valuable assistance in collecting the type material.

Distribution.—Claiborne group, McBean

formation: GEORGIA, *Burke County:* U. S. G. S. sta. 5296, Sloan's Scarp, McBean Creek.

Claiborne group, Lisbon formation. ALABAMA, *Choctaw County:* U. S. G. S. sta. 7882, Okatippa Creek, ½ mile above crossing, 1½ miles north of Barrytown. *Monroe County:* U. S. G. S. stas. 3105, 5511 and 6086, Lisbon Bluff, Alabama River; U. S. G. S. stas. 13431 and 14215, Lisbon Bluff, bed 7 of the Cooke section.

TURRITELLA NASUTA HOUSTONIA Harris

Plate 32, figures 2, 3

Turritella nasuta var. *houstonia* Harris. DUMBLE, *1894*, Jour. Geology, vol. 2, p. 552.—HARRIS, *1895*, Acad. Nat. Sci. Philadelphia, Proc. for 1895, p. 81, pl. 9, fig. 6.—TROWBRIDGE, *1932*, U. S. Geol. Survey, Bull. 837, p. 131, pl. 42, fig. 8.—PALMER, *1937*, Bull. Am. Paleontology, vol. 7, no. 32, p. 201, pl. 25, figs. 4, 7, 11.

Shell small. Spire high, acute, gently tapering. Whorls numerous, wider than high, rounded slightly. Sutures linear but distinct, constricting the whorls, but not deeply impressed. Apical whorls marked by two prominent subequal revolving lirae with a smaller, less prominent revolving lira posterior to them; late adolescent and adult whorls sometimes marked by just these primary lirae, stronger, but relatively as prominent as on the apical whorls; additional lirae appearing in adolescence, however, on some individuals, variously placed with respect to the primaries, occasionally assuming prominence on the adult whorls equal to that of the primaries and obscuring the tricarinate sculpture characteristic of the adult whorls of more typical specimens. Incrementals distinct but not prominent, arcuate, the maximum curvature attained at about the median of the whorl, slightly reflexed just behind the suture. Aperture rounded. Outer lip thin and fragile, not preserved entire.

Dimensions: Not given by Harris for the holotype. Figured specimens, U. S. Nat. Mus. no. 498014, height, 14.5 mm; greatest diameter, 5.0 mm (specimen broken at apex and aperture). U. S. Nat. Mus. no. 498015, height, 19.0 mm; greatest diameter, 5.0 mm (specimen broken slightly at apex and aperture).

Type material: A holotype in the collection of the Texas State Museum, Austin, Texas. Two figured specimens, U. S. Nat. Mus. nos. 498014, 498015.

Type locality: (according to Harris) Alabama Bluff, Trinity River, Houston County, Alabama. Figured specimens: U. S. Nat. Mus. no. 498014, a topotype. U. S. Nat. Mus. no. 498015, from U. S. G. S. sta. 10734, Orells Crossing, Elm Creek, Lee County, Texas. Claiborne group, upper Cook Mountain.

Turritella nasuta houstonia was originally described by Harris as follows:

> This variety differs from typical *nasuta* in being much broader at base, and having its whorls rounded or slightly carinated submedially. It is generally somewhat larger than the typical form, and is closely related to Conrad's "*Mesalia lintea*" (Harris, 1895, p. 81).

Harris must have been referring to a specimen in the Philadelphia Academy of Natural Sciences labelled *Mesalia lintea* by Conrad, as the species was never described, the nude name appearing only in Conrad's check lists (Conrad, 1865, 1866; Palmer, 1937).

The subspecies *houstonia* differs from typical *nasuta*, as Harris pointed out, in its rounded whorls, and also in the less numerous revolving lirae on the adult whorls, the tripartite apical sculpture usually continuing throughout the growth of the shell. Harris and Palmer record the species from numerous Texas localities, but it is recorded in the collections of the National Museum only from the upper Cook Mountain beds of Orell's Crossing on Elm Creek and Alabama Crossing on the Trinity River and from Moseley's Ferry. Harris also recorded the species from the McBean formation of South Carolina, but there is nothing in the National Museum collections comparable to the material from Alabama Crossing. Veatch and Stephenson (1911, p. 240; 1915 p. 76) have listed *Turritella nasuta houstonia* from the McBean formation of Georgia, but the specimens so identified are probably more correctly referable to *Turritella lisbonensis*, or *Turritella nasuta felli*.

The name *Turritella nasuta houstonia* was first used in print by Dumble in 1894, but he probably obtained it from Harris's Texas manuscript or from labelled specimens in the Texas State Museum, as he ascribed

the species to Harris. No description or figure accompanied Dumble's citation, so the subspecies dates from Harris's original description the following year.

Distribution.—Claiborne group. Cook Mountain formation. TEXAS, *Houston County:* U. S. G. S. sta. 10738, Alabama Crossing, Trinity River, 10 miles west of Porters Springs; bed no. 5, upper 12 to 18 inches. *Brazos County:* Moseleys Ferry, now Stone City, Brazos River. *Lee County:* U. S. G. S. stas. 10517, and 10734, Orell's Crossing, Elm Creek, 5.2 miles northwest of Giddings.

TURRITELLA EURYNOME Whitfield

Plate 31, figure 13; plate 32, figure 18

Turritella eurynome WHITFIELD, *1865*, Am. Jour. Conchology, vol. 1, p. 266.—DEGREGORIO, *1890*, Faune éocénique de l'Alabama, pp. 127, 128.—ALDRICH, *1894*, Alabama Geol. Survey, Rept. for 1894, p. 237 (Not p. 233 = *Turritella rina subrina* Palmer).—HARRIS, *1899*, Bull. Am. Paleontology, vol. 3, no. 11, p. 75, pl. 10, fig. 7.

Turritella sp. PLUMMER, *1933*, Univ. Texas, Bull. 3232, p. 815, pl. 10, fig. 9.

Spire high, narrow, very gradually tapering. Whorls straight-sided, wider than high. Sutures linear, distinct, not deeply impressed. Apical whorls marked by three prominent subequal revolving lirae, the two anterior more distantly placed from the posterior than they are from each other; a fourth lira arising just in front of the posterior suture very early in the shell growth, rapidly increasing in strength until on the adult whorls it is about the same size as the three primary cords; on some specimens this posterior cord becoming very strong and forming a slight keel, approximating the carina of *Turritella bellifera;* the four cords of the adult whorls arranged in pairs, the wide medial portion between these pairs marked by a fine revolving line; another secondary line appearing on the adult whorls between the two anterior primary cords; a third secondary line appearing occasionally between the anterior primary lira and the anterior suture; base of body whorl marked by three or four indistinct cords. Incremental striae not distinct, deeply recurved at about the posterior third of the whorl and again bent backward just behind the suture. Aperture not preserved entire on any of the specimens examined.

Dimensions: Cotype, height, 27.5 mm; greatest diameter, 11.5 mm. Figured specimen, height, 52.0 mm; greatest diameter, 11.5 mm. The cotype is a very incomplete individual with only three whorls preserved. The figured specimen is almost complete, being but slightly broken at the apex and aperture.

Type material: A number of cotypes in the Hall collection of the Walker Museum of the University of Chicago, no. 24505. Figured specimen, U. S. Nat. Mus. no. 498001.

Type locality: Six miles above Claiborne, Alabama, on the west side of the river. (Whitfield, 1865) This locality falls within the outcrop of the Claiborne, but, as Aldrich (1887, p. 81) has pointed out, most of Whitfield's localities are incorrect. The cotype were generously loaned me by the University of Chicago. This type material exactly matches the material in the collections of the National Museum from Bell's Landing, and the types probably came from that locality. There is nothing in the Claiborne with which this form could be readily confused. Figured specimen, U. S. G. S. sta. 3098, Bells Landing, Alabama River, Monroe County, Alabama. Wilcox group, Tuscahoma sand.

When typically developed, *Turritella eurynome* is quite distinct from any of the other *Turritellas* of the Wilcox, and the straight-sided whorls with four prominent revolving lirae in the adult stages well characterize the species. Occasionally, however, the posterior lira becomes strongly developed and approximates the prominent carina of *T. bellifera*, a species with which *T. eurynome* is associated at Bells and Greggs Landings. The trilirate apical whorls, however, readily distinguish this species from *T. bellifera* and the other members of the *T. humerosa* group, and the lack of a basal carination separate it from the tricostate group of *Turritella mortoni.*

Whitfield never figured his type material of *Turritella eurynome*, and the first figure of the species was that of Harris in 1899.

Distribution.—Wilcox group, Tuscahoma sand. ALABAMA, *Wilcox County:* U. S. G. S. stas. 268 and 3118, Greggs Landing, Ala-

bama River; U. S. G. S. stas. 260, 3098, 5593 and 5594, Bells Landing, Alabama River.

TURRITELLA MORTONI SUBGROUP

TURRITELLA MORTONI Conrad

Plate 33, figure 14

Turritella mortoni CONRAD, *1830*, Acad. Nat. Sci. Philadelphia, JOUR., vol. 6, pp. 213, 214, 215, 221. pl. 10, fig. 2.—CONRAD *1835, ex parte*, Fossil shells (republication), p. 40 (Not pl. 15, fig. 11 = *Turritella carinata* Isaac Lea).—DE-GREGORIO, *1890, ex parte*, Faune éocénique de l'Alabama, pp. 122, 123, pl. 11, fig. 7 (Not pl. 11, figs. 3, 4, 5, 6, 9 = *Turritella carinata* Isaac Lea).—HARRIS, *1894*, Am. Jour. Sci., 3rd ser., vol. 47, no. 280, pp. 302, 303, text fig. 3.—COSSMANN, *1894*, Notes comp. sur la faune éocénique de l'Alabama, p. 29.—CLARK, *1896*, U. S. Geol. Survey, Bull. 141, pp. 40, 41, 42, 43, 45, 46, 57, 69, 70; pl. 13, figs. 1a–1e.—CLARK, and MARTIN, *1901*, Maryland Geol. Survey, Eocene, pp. 147, 148, pl. 26, figs. 1–5.—VEATCH, *1906, ex parte*, U. S. Geol. Survey, Prof. Paper 46, pl. 14, fig. 5a (Not pl. 14, fig. 5 = *Turritella mortoni postmortoni* Harris).—CLARK, and MILLER, *1912*, Virginia Geol. Survey, Bull. 4, pp. 92, 93, 94, 95, 96, 97, 98, 99, 100, 102, 119. 120.—GUILLAUME, *1924, ex parte*, Soc. géol. de France, Bull., ser. 4, vol. 24, pp. 289, 290.—GUILLAUME, *1926*, Soc. géol. de France, Bull., ser. 4, vol. 26, p. 425.—Not ALDRICH, *1886*, Alabama Geol. Survey, Bull. 1, pp. 9, 13, 46, 55, 58, 59, 60. (= *Turritella mortoni postmortoni* Harris).—NOT HARRIS, *1899*, Bull. Am. Paleontology, vol. 3, no. 11, pp. 74, 75, 76, pl. 10, figs. 3, 4 (= *Turritella mortoni postmortoni* Harris).—Not HARRIS, *1900*, Louisiana Geol. Survey, Rept. for 1899, pp. 299, 308, pl. 52, fig. 9; pl. 55, fig. 4 (= *Turritella mortoni postmortoni* Harris).—Not COOKE, *1926*, Alabama Geol. Survey, Spec. Rept. 14, pp. 259, 261, 264, pl. 94, fig. 2 (= *Turritella mortoni postmortoni* Harris).

Turritella mortoni var. *postmortoni* Harris. CLARK and MARTIN, *1901*, Maryland Geol. Survey, Eocene, pl. 26, fig. 5 (Not *Turritella mortoni* var. *postmortoni* Harris, 1894).

Turritella (*Haustator*) *mortoni* COSSMANN, *1912, ex parte*, Paléoconchologie comparée, vol. 9, pp. 115, 118.

Shell large for the genus. Spire high, robust, gently tapering. Sutures narrow, deeply impressed; whorls much wider than high, sharply keeled anteriorly in the adult stages. Apical whorls marked by three distinct revolving lirae, the anterior becoming relatively much the strongest with the growth of the shell and forming a distinct carina on the seventh or eighth whorls; carination sufficiently strong on the adult whorls to sharply angulate them; spirals augmented on the third or fourth whorl by a secondary lira between the two primary posterior cords; additional lirae appearing on the later whorls variously placed with respect to the primary cords until on the adult whorls there are ten or eleven revolving lirae between the anterior carination and the posterior suture, the primary lirae, with the exception of the primary carina, being but little stronger than the accessory cords; under surface of carina bare at inception, a lira appearing on it at about the eleventh whorl with others following in quick succession until on the body whorl of the largest specimen observed there are four large lirae with two or three indistinct threads between them; base of body whorl marked by four or five additional lirae. Incrementals strongly flexed at about the posterior third of the whorl, and reflexed distinctly just behind the anterior suture. Parietal callus well developed. Outer lip rarely preserved, not entire on any of the specimens at hand.

Dimensions: Measurement of holotype not given by Conrad. Figured specimen, height, 98.0 mm; greatest diameter, 26.5 mm.

Type material: A lectotype and four paratypes in the collection of the Philadelphia Academy of Natural Science. Figured specimen: U. S. Nat. Mus. no. 497990.

Type locality: (according to Conrad) Piscataway, Prince Georges County, Maryland. Figured specimen: U. S. G. S. sta. 13235, Fairview Beach, east of Fredericksburg, Stafford County, Virginia. Wilcox Group, Aquia formation.

Turritella mortoni was one of the first species to be described from the Eocene of North America, antedating by three years the great Claibornian monographs of Conrad and the elder Lea. It is one of the most characteristic of Eocene fossils, and the bibliographic references to it are multitudinous. It is impossible to take cognizance of all the literature in the relatively brief space permitted a synonymy, and I have selected just a few of the most important references. The name has been utilized widely, more in the sense of the group of basally carinate Paleocene and lower Eocene turritellas than as a distinct specific entity. The Midway members of the group include

Turritella alabamiensis Whitfield, *T. hilli* Gardner, and *Turritella mortoni mediavia* Bowles, with the probable addition of *T. levicunea* Harris and *T. kincaidensis* Plummer.

As restricted in this paper, *Turritella mortoni* is found only in the Aquia formation of Maryland and Virginia. In the lower Wilcox of Alabama the group is represented by the extremely abundant subspecies, *T. mortoni postmortoni* Harris. This southern form differs from typical *T. mortoni* in its sharper and more basal carination and in its much less prominent adult sculpture. The close relationship is evidenced not only by the similarity of the general whorl outlines but by the closely analogous apical sculpture. The citations of "*Turritella mortoni*" from the Nanafalia and Tuscahoma of Alabama, and the lower Eocene deposits of the Sabine Uplift region of East Texas should be transferred to *T. mortoni postmortoni* Harris.

Clark and Martin in their volume on the Maryland Eocene figure a sharply keeled specimen under the name "*Turritella mortoni* var. *postmortoni* Harris." The differences, however, between this sharply angulated form and the type are probably due more to the relative ages of the different individuals than to separate specific identities. The angulation of the keel of *T. mortoni* is subject to great variation. No keel is evident on the earliest whorls, but the keel rapidly becomes prominent after its inception on the tenth whorl. On the adolescent whorls it is very sharp and strong, but on the adult whorls the carina is more rounded and more distant from the anterior suture. Were it not for the fact that long suites of specimens indicate all the intermediate stages between these specimens with very sharp carinae and those whose keels are more rounded, it might be practicable to recognize the differences taxonomically. It is possible that more than one species is represented in the *T. mortoni* group of Maryland and Virginia, but since it is widely recognized that closely related species rarely share the same habitat it seems more logical to account for the slight differences noted in the group in the Middle Atlantic Eocene by individual variation.

Turritella potomacensis Clark and Martin from the Nanjemoy formation of the Maryland Wilcox is probably a descendant of the *Turritella humerosa* stock of the Aquia, rather than of the *T. mortoni*, as the apical whorls are multicostate instead of tricostate. The whorls are slightly carinate basally, however, and the relationships of the form are somewhat obscure.

Distribution.—Wilcox group, Aquia formation. MARYLAND, *Anne Arundel County:* U. S. G. S. sta. 3934, South River, 2½ miles from Annapolis. *Charles County:* U. S. G. S. sta. 2243, Glymont, Potomac River; U. S. G. S. sta. 2349, east bank of Potomac River, two-thirds of a mile above Clifton Beach. *Prince George County:* U. S. G. S. sta. 2029, ravine, 1 mile east of Fort Washington; U. S. Nat. Mus. no. 11425, Fort Washington; U. S. G. S. stas. 2145 and 13451, Piscataway Creek; U. S. G. S. stas. 3272 and 3692, Upper Marlboro; U. S. G. S. sta. 4016, Tinker Creek, near Friendly Postoffice.

VIRGINIA, *Stafford County:* U. S. G. S. stas. 2031, 13809 and 13810, bluffs on the Potomac River at mouth of Aquia Creek; U. S. Nat. Mus. no. 2503, Aquia Creek; U. S. G. S. sta. 2346, Potomac River, south bank, just southeast of the mouth of Potomac Creek; U. S. G. S. sta. 2347, Western bank of Potomac River, about two-thirds of a mile north of the mouth of Potomac Creek; U. S. G. S. sta. 12974, Stafford Courthouse; U. S. G. S. sta. 13235, Fairview Beach, east of Fredricksburg.

TURRITELLA MORTONI MEDIAVIA
Bowles, n. subsp.
Plate 33, figures 3, 5

?Turritella mortoni Conrad, var. HARRIS, *1894*, Arkansas, Geol. Survey, Ann. Rept. for 1892, pt. 2, p. 48, pl. 3, fig. 5.

Turritella mortoni Conrad. ?HARRIS, *1894*, Arkansas Geol. Survey, Ann. Rept. for 1892, pt. 2, pp. 47–48.—?HARRIS, *1896*, Bull. Am. Paleontology, vol. 1, no. 4, pp. 16, 17.—MCCALLIE, *1908*, Georgia Geol. Survey, Bull. 15, p. 235.—VEATCH and STEPHENSON, *1911*, Georgia Geol. Survey, Bull. 26, pp. 219, 220.—STEPHENSON and VEATCH, *1915*, U. S. Geol. Survey, Water-Supply Paper 341, p. 69.—?STEPHENSON and CRIDER, *1916*, U. S. Geol. Survey, Water-Supply Paper 399, pp. 48, 49, 51–53.—BRANTLY, *1920*, Alabama Geol. Survey, Bull. 22, pp. 145, 146 (only).—?LOWE, *1933, ex parte*, Mississippi Geol. Survey, Bull. 25, p. 11.—COOKE, *1936*, U. S. Geol. Survey, Bull. 867, p. 50. Not CONRAD, *1830*.

?Turritella saffordi Gabb. HARRIS, *1896*, Bull. Am. Paleontology, vol. 1, no. 4, p. 110, pl. 11, fig. 8 (cited in plate description as *T. mortoni* var.) Not GABB, 1860.

Spire abruptly tapering for the genus. Apical whorls sharply angulated anteriorly, concave in profile; adult whorls more rounded, almost convex in profile, sharply constricted at the sutures, which are linear but distinctly impressed between the apical whorls, gradually becoming deeper and wider between the later whorls. Sculpture of apical whorls consisting of a strong basal carina with a less prominent revolving cord near the posterior suture; both the carina and the posterior cord persistent on the adult whorls, the posterior giving the whorls a more rounded appearance than is general in the group. Secondary sculpture consisting of numerous very fine revolving lines, beaded on some of the early whorls by the intersection of the growth lines. Incremental striae distinct and sharply flexed medially, curving out again and then slightly reflexed at the anterior suture. Aperture unknown.

Dimensions: Holotype, height, 41.0 mm; greatest diameter, 19.0 mm; paratype, height, 44.0 mm; greatest diameter, 25.0 mm. Both specimens are incomplete, broken at the apex and the aperture.

Type material: A holotype, U. S. Nat. Museum no. 495146, and a paratype, U. S. Nat. Mus. no. 495147.

Type locality: U. S. G. S. sta. 264, Prairie Creek, Wilcox County, Alabama. Midway group, Clayton formation.

Turritella mortoni mediavia differs from typical *T. mortoni* and the subspecies *post-mortoni* of the Wilcox in the persistence of the fairly strong secondary carina that makes the profile of the whorls more rounded than in either of the Wilcox forms. There are a number of very well preserved tips in the collection (U. S. Nat. Mus. no. 129569) from Prairie Creek that clearly show the two strong carinae on the early whorls.

Harris (1894, pp. 47, 48) lists *Turritella mortoni* Conrad from numerous Midway localities in Arkansas. These collections are in the National Museum and comprise U. S. Geol. Survey stas. 2218, 2229, 2230, 2233, 2433, 2435, and 2437. All this material is very poorly preserved, but the molds and casts seem to have closer affinities to *T. mediavia* than to any other species. The specimen figured by Harris as "*Turritella mortoni* var." is a much weathered specimen and is probably not even subspecifically distinct from the other forms. Harris (1896, pl. 11, fig. 8) republished this figure, referring it to *Turritella saffordi* Gabb.

The specimens from U. S. G. S. sta. 6581, 7 miles south of Macon on the Macon-DeKalb road, Noxubbee County, Mississippi, referred by Stephenson, in 1914, and, Lowe, in 1933, to *T. mortoni* seem to have close affinities to *T. mortoni mediavia*, but the material is too poorly preserved to be specifically identifiable.

The well-preserved specimen (U. S. Nat. Mus. no. 497988) from near Pinewood, Sumter County, South Carolina, recovered from deposits of Black Mingo age, is identical in every way with the holotype of *Turritella mortoni mediavia*. Cooke, in 1936 placed the Black Mingo tentatively in the Wilcox Group, as the possible equivalent of the Tuscahoma sand. The fossils of the Black Mingo are very poorly preserved, and they have not been intensively studied, so that they have yielded little evidence of the exact age of the formation. The presence of *T. mortoni mediavia*, however, in conjunction with other members of the Turritellidae commonly associated with the Midway faunas, lends credence to a view that the Black Mingo may be of lower Midway rather than of Wilcox age.

The material collected by Stephenson in 1909 (U. S. G. S. sta. 5478) in Clay County, Georgia, and referred to "*Turritella mortoni* Conrad" in his report on the underground waters of the Coastal Plain of Georgia (Stephenson and Veatch, 1915, p. 69) is identical with the holotype of *T. mortoni mediavia* from Alabama. In 1908 McCallie cited *Turritella mortoni* Conrad from Macon County, Georgia. This material is in the collection of the U. S. National Museum (U. S. G. S. sta. 3994) and the specimens prove to be *T. mortoni mediavia*, as now defined.

Distribution.—Midway group, Black Mingo formation. SOUTH CAROLINA, *Sumter County:* U. S. G. S. sta. 10401, about 3½ miles west of Pinewood. *Clarendon County:*

Explanation of Plate 31

Figs. *1, 3—Turritella lisbonensis* Bowles, n. sp. *1*, Holotype, U. S. Nat. Mus. 498009, from Lisbon Bluff, Alabama River, Monroe County, Ala., ×2. *3*, Early whorls of holotype, ×3. (p. 286)

2—Turritella dutexata Harris. Lectotype, U. S. Nat. Mus. 497952, from five miles southeast of Franklin, Robertson County, Texas, ×2. (p. 285)

4—Turritella apita DeGregorio. Topotype, U. S. Nat. Mus. 494978, from the Moodys marl at Claiborne, Ala., ×2. (p. 275)

5-7—Turritella arenicola (Conrad). *5*, Early whorls of U. S. Nat. Mus. 495144, from White Bluff, Jefferson County, Ark., ×3. *6*, Apertural view of same specimen as *5*, ×2. *7*, Specimen, U. S. Nat. Mus. 498002, from Garland Creek, 4 miles north-northeast of Shubuta, Clarke County, Miss., ×2. (p. 275)

8, 14—Turritella wechesensis Bowles, n. sp. *8*, Juvenile paratype, U. S. Nat. Mus. 497959, from Percilla, Houston County, Texas, ×3. *14*, Holotype, U. S. Nat. Mus. 497958, from Percilla, Houston County, Texas, ×2. (p. 281)

9, 12—Turritella clevelandia Harris. *9*, Early whorls of lectotype, U. S. Nat. Mus. 498010, from White Bluff, Jefferson County, Ark., ×3. *12*, Same specimen as *9*, ×2. (p. 308)

10—Turritella martinensis Dall. Lectotype, U. S. Nat. Mus. 498390, from the Ocala limestone at Martin Station, Hernando County, Fla., ×1½. (p. 282)

11, 15—Turritella cortezi Bowles, n. sp. *11*, Paratype, U. S. Nat. Mus. 495173, from 7.2 kilometers southwest of Mier, Tamaulipas, Mexico, ×2. *15*, Holotype, U. S. Nat. Mus. 495172, from 7.2 kilometers southwest of Mier, Tamaulipas, Mexico, ×2. (p. 280)

13—Turritella eurynome Whitfield. U. S. Nat. Mus. 498011, from Bells Landing, Alabama River, Monroe County, Ala., ×2. (p. 292)

16—Turritella rina subrina Palmer. U. S. Nat. Mus. 495171, from base of bluff at Claiborne, Ala., ×2. (p. 279)

17—Turritella rina Palmer. Topotype, U. S. Nat. Mus. 495170, from base of bluff at Claiborne, Ala. (p. 277)

Explanation of Plate 32

Fig. *1—Turritella alveata* Conrad. Topotype, U. S. Nat. Mus. 498001, from Jackson Miss., ×2. (p. 306)

2, 3—Turritella Nasuta houstonia Harris. *2*, U. S. Nat. Mus. 498015, from Orells Crossing, Elm Creek Lee County, Texas, ×3. *3*, Topotype, U. S. Nat. Mus. 498014, from Alabama Bluff, Trinity River, Houston County, Texas, ×3. (p. 291)

4, 8—Turritella nasuta felli Bowles, n. subsp. *4*, Early whorls of U. S. Nat. Mus. 498006, from Little Brazos River, Brazos County, Texas, ×3. *8*, Holotype, U. S. Nat. Mus. 498005, from Lisbon Bluff, Alabama River, Monroe County, Ala., ×2. (p. 290)

5, 6—Turritella nasuta Gabb. *5*, Early whorls of U. S. Nat. Mus. 498004, from Little Brazos River, Brazos County, Texas, ×3. *6*, Same specimen, ×5. (p. 288)

7, 13—Turritella nasuta smithvillensis Bowles, n. subsp. *7*, Holotype, U. S. Nat. Mus. 497998, from Smithville, Bastrop County, Texas, ×2. *13*, Paratype, U. S. Nat. Mus. 497999, from Smithville, Bastrop County, Texas, ×4. (p. 289)

9, 19—Turritella dumblei Harris. U. S. Nat. Mus. 498003, from one mile east of Jourdanton, Atascosa County, Texas, ×2. *19*, Another from same lot, ×2. (p. 303)

10—Turritella mingoensis Bowles, n. sp. Holotype, U. S. Nat. Mus. 497953, from 1.2 miles south of Rhems, Georgetown County, S. C., ×2. (p. 319)

11—Turritella perdita Conrad. U. S. Nat. Mus. 498000, from Moodys Branch, Jackson, Miss., ×2. (p. 307)

12—Turritella tennesseensis Gabb. U. S. Nat. Mus. 497989, from 1½ miles east of Middleton, Hardeman County, Tenn., ×2. (p. 284)

14—Turritella vaughani Bowles, n. sp. Holotype, U. S. Nat. Mus. 497955, from 5.1 miles north of Orangeburg, Orangeburg County, S. C., ×4. (p. 282)

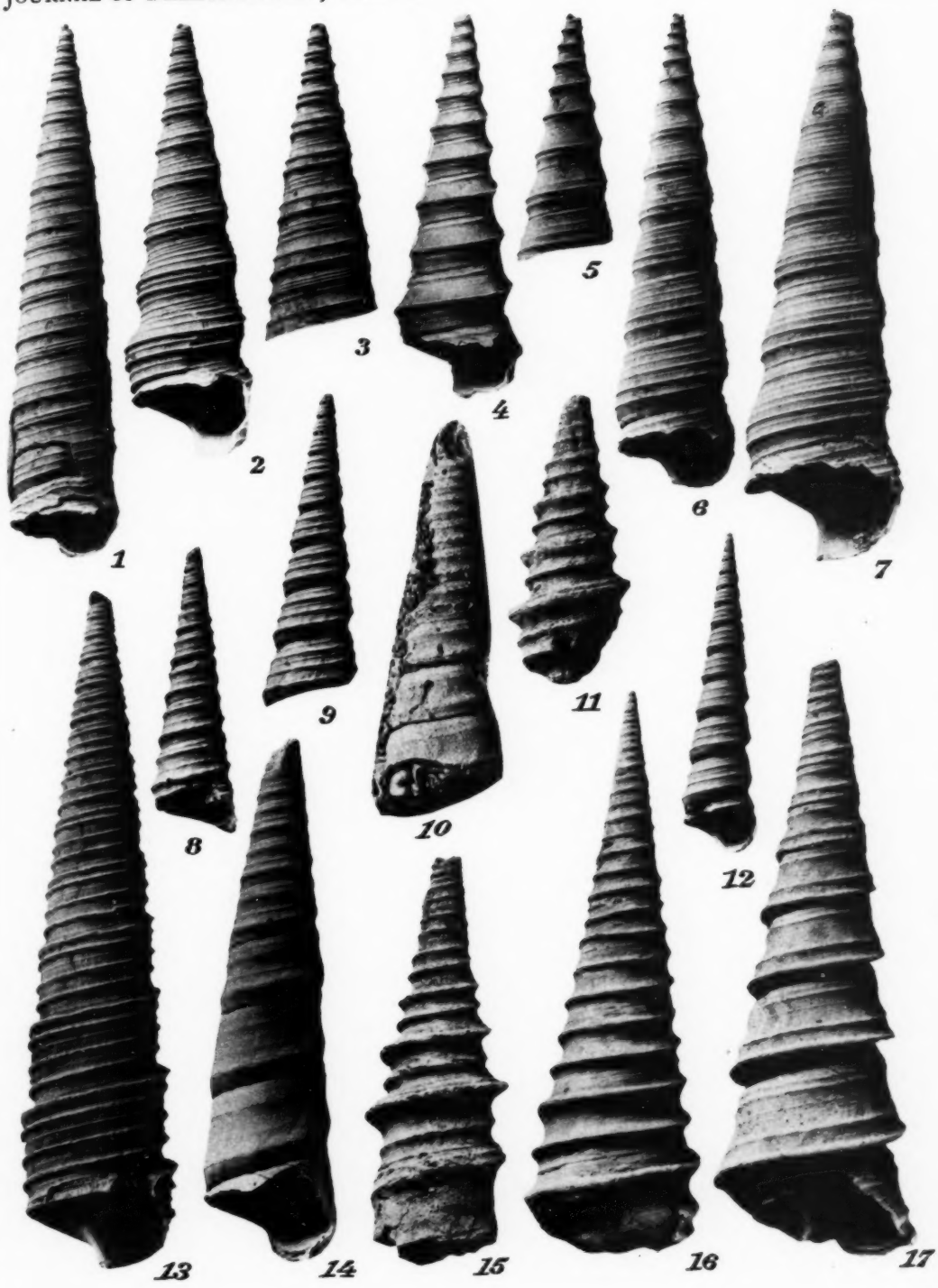
15—Turritella multilira Whitfield. Cotype, Walker Museum, Univ. Chicago, possibly from Nanafalia Bluff, Alabama River, Marengo County, Ala., ×1. (p. 316)

16—Turritella gilberti Bowles, n. sp. Holotype, U. S. Nat. Mus. 494993, from Woods Bluff, Alabama River, Clarke County, Ala., ×2. (p. 302)

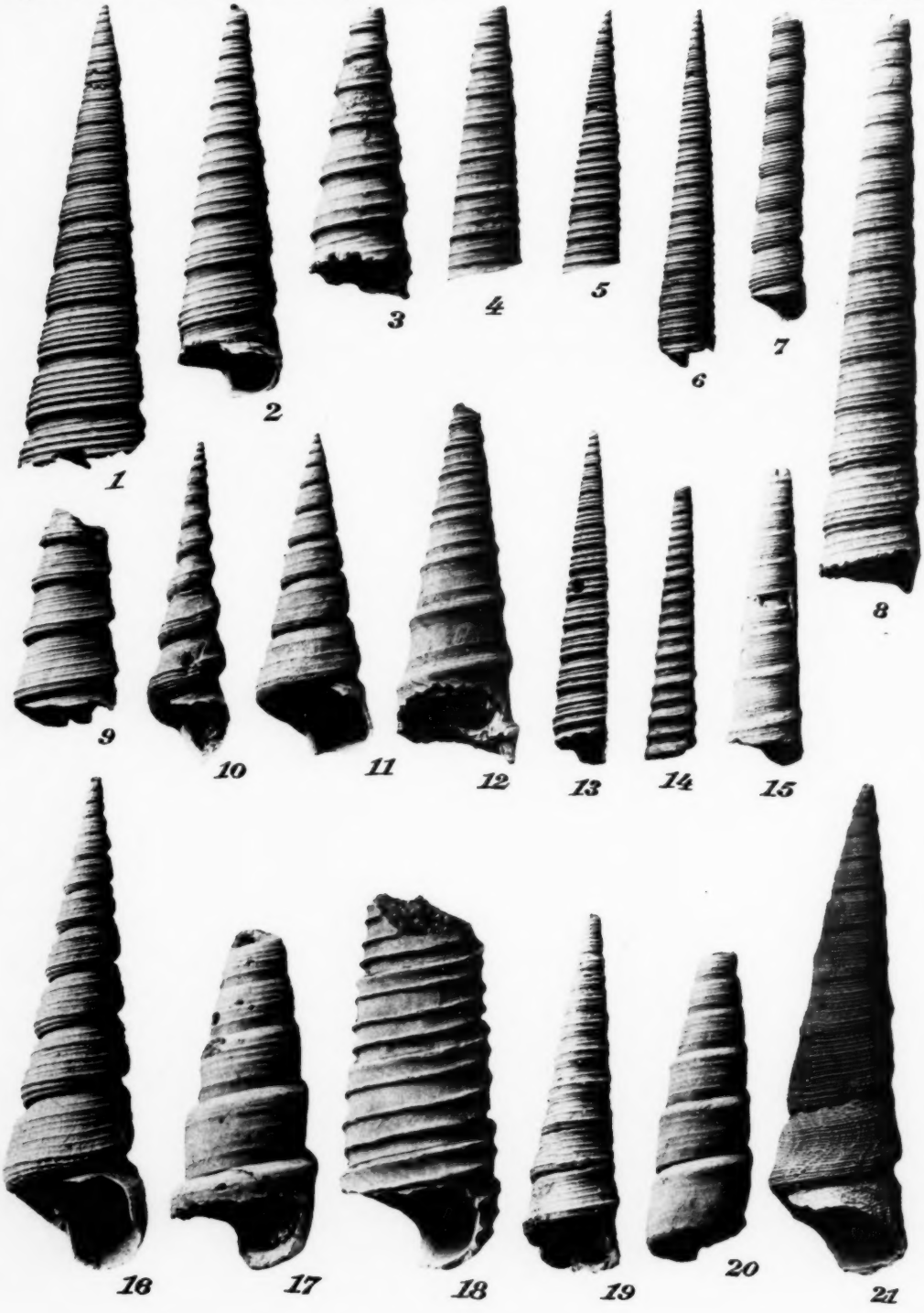
17, 20—Turritella mcbeanensis Bowles, n. sp. Paratype, U. S. Nat. Mus. 497957, from Stroman's Mill, 5 miles east of Springfield, Orangeburg County, S. C., ×3. *20*, Holotype, U. S. Nat. Mus. 497956, from Stroman's Mill, ×2. (p. 319)

18—Turritella eurynome Whitfield. Cotype, Walker Museum Univ. Chicago, probably from Bells Landing, Alabama River, Monroe County, Ala., ×2. (p. 292)

21—Turritella alabamiensis Whitfield. Cotype, Walker Museum, Univ. Chicago, probably from Matthews Landing, Alabama River, Wilcox County, Ala., ×2. (p. 299)

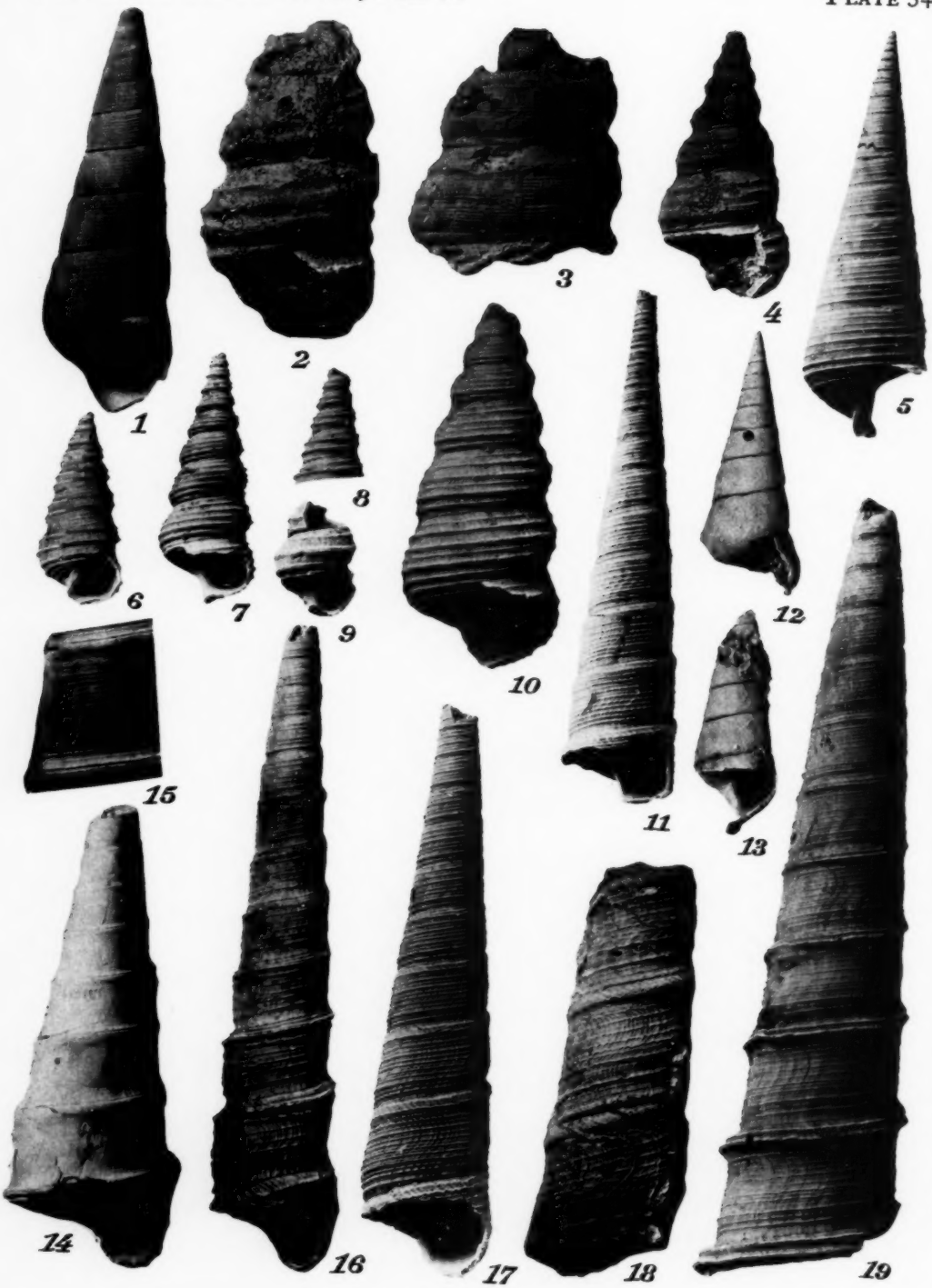


Bowles, Early Tertiary Turritellidae



Bowles, Early Tertiary Turritellidae

Bowles, Early Tertiary Turritellidae



Bowles, Early Tertiary Turritellidae

Explanation of Plate 33

FIGS. *1, 8—Turritella saffordi* Gabb. *1*, U. S. Nat. Mus. 495151, from 3 miles northwest of Ripley, Tippah County, Miss., ×1. *8*, U. S. Nat. Mus. 495152, from milepost 481, east of Middleton, Hardeman County, Tenn., ×3. (p. 309)

2—Turritella obruta Conrad. Topotype, U. S. Nat. Mus. 497996, from the Moodys marl at Claiborne, Ala., ×2. (p. 311)

3, 5—Turritella mortoni mediavia Bowles, n. subsp. *3*, U. S. Nat. Mus. 497988, from 3½ miles west of Pinewood, Sumter County, S. C., ×1. *5*, Holotype, U. S. Nat. Mus. 495146, from Prairie Creek, Wilcox County, Ala., ×2. (p. 294)

4—Turritella mortoni postmortoni Harris. Topotype, U. S. Nat. Mus. 497992, from Bells Landing, Monroe County, Ala., ×1. (p. 298)

6—Mesalia sayi Bowles, n. sp. Holotype, U. S. Nat. Mus. 494798, from south of Río San Juan, Nuevo León, Mexico, ×1½. (p. 334)

7—Turritella pleboides Vaughan. Lectotype, U. S. Nat. Mus. 495175, from Mount Lebanon, Bienville Parish, La., ×2. (p. 311)

9—Mesalia gomin Bowles, n. sp. Holotype, U. S. Nat. Mus. 497954, from two miles west of Catchall, Sumter County, S. C., ×2. (p. 326)

10—Turritella humerosa Conrad. Topotype, U. S. Nat. Mus. 497994, from Piscataway, Prince Georges County, Md., ×1. (p. 312)

11—Turritella praecincta Conrad. U. S. Nat. Mus. 497991, from Bells Landing, Monroe County, Ala., ×1. (p. 318)

12—Turritella carinata palmerae Bowles, n. subsp. Holotype, U. S. Nat. Mus. 497997, from Lisbon Bluff, Alabama River, Monroe County, Ala., ×2. (p. 305)

13—Turritella carinata Lea. Topotype, U. S. Nat. Mus. 497995, from the Moodys marl at Claiborne, Ala., ×2. (p. 304)

14—Turritella mortoni Conrad. U. S. Nat. Mus. 497990, from Fairview Beach, Stafford County, Va., ×1. (p. 293)

Explanation of Plate 34

FIG. *1—Mesalia vetusta* (Conrad). Topotype, U. S. Nat. Mus. 494979, from the Moodys marl at Claiborne, Ala., ×2. (p. 331)

2–4—Mesalia wilcoxiana (Aldrich). *2*, Holotype, Aldrich Coll., Johns Hopkins Univ., from Prairie Creek, Wilcox County, Ala., ×2. *3*, Holotype of *M. allentonensis* (Aldrich), Aldrich Coll., Johns Hopkins Univ., from Prairie Creek, Wilcox County, Ala., ×2. *4*, Paratype of *M. allentonensis* (Aldrich), Aldrich Coll., Johns Hopkins Univ., from Prairie Creek, Ala., ×2. (p. 324)

5—Mesalia claibornensis Harris. U. S. Nat. Mus. 497985, from Lisbon Bluff, Alabama River, Monroe County, Ala., ×2. (p. 328)

6, 8—Mesalia biplicata Bowles, n. sp. *6*, Holotype, U. S. Nat. Mus. 494990, from Nanafalia, Marengo County, Ala., ×1. *8*, Early whorls of paratype, U. S. Nat. Mus. 494991, from Nanafalia, Marengo County, Ala., ×2. (p. 328)

7—Mesalia pumila (Gabb). U. S. Nat. Mus. 497984, from Prairie Creek Wilcox County, Ala., ×3. (p. 325)

9—Mesalia hardemanensis (Gabb.). U. S. Nat. Mus. 497986, from 1½ miles east of Middleton, Hardeman County, Tenn., ×2. (p. 333)

10—Mesalia alabamiensis (Whitfield). Cotype, Walker Museum, Univ. Chicago, locality unknown, ×2. (p. 327)

11, 17—Turritella aldrichi Bowles, n. sp. *11*, Holotype, U. S. Nat. Mus. 495148, from Matthews Landing, Wilcox County, Ala., ×2. *17*, Paratype, U. S. Nat. Mus. 495149, same locality, ×2. (p. 315)

12, 13—Mesalia georgiana Bowles, n. sp. *12*, Paratype, U. S. Nat. Mus. 498007, from nine miles southeast of Louisville, Jefferson County, Ga., ×1. *13*, Holotype, U. S. Nat. Mus. 498008, from 7.5 miles southeast of Louisville, Jefferson County, Ga., ×1. (p. 333)

14, 15—Turritella claytonensis Bowles, n. sp. *14*, Holotype, U. S. Nat. Mus. 131637, from Prairie Creek, Wilcox County, Ala., ×1. *15*, Sculpture detail of holotype, ×3. (p. 314)

16—Turritella bellifera Aldrich. Holotype, Aldrich Coll., Johns Hopkins Univ., from Bells Landing, Alabama River, Monroe County, Ala., ×1. (p. 317)

18—Turritella humerosa sanjuanensis Bowles, n. subsp. Holotype, U. S. Nat. Mus. 494986, from Río San Juan, Nuevo León, Mexico, ×2. (p. 314)

19—Turritella multilira Whitfield. Possible topotype, U. S. Nat. Mus. 498012, from Nanafalia Bluff, Alabama River, Marengo County, Ala., ×2. (p. 316)

U. S. G. S. sta. 10403, Kingstree Road, east of Deep Creek, 5 miles east of Manning.

Midway group, Clayton formation GEORGIA, *Clay County:* U. S. G. S. sta. 5478, on right bank of Chattahoochee River, near Morris Landing, about 7 miles above Ft. Gaines, collected at the water's edge during a low level of the river. *Macon County:* U. S. G. S. sta. 3994, Flint River at the county bridge, 1 mile northwest of Montezuma. ALABAMA, *Wilcox County:* U. S. G. S. sta. 264, Prairie Creek.

TURRITELLA MORTONI POSTMORTONI Harris

Plate 33, figure 4

Turritella mortoni var. *postmortoni* HARRIS, *1894*, Am. Jour. Sci., 3d ser., vol. 47, no. 280, pp. 302–304, text fig. 1 (Not text fig. 3 = *Turritella mortoni* Conrad).—HARRIS, *1899*, Bull. Am. Paleontology, vol. 3, no. 11, p. 75, pl. 10, fig. 3.—CLARK and MARTIN, *1901*, Maryland Geol. Survey, Eocene, pp. 147, 148 (Not pl. 26, fig. 5 = *Turritella mortoni* Conrad). Not GRABAU and SHIMER, *1909*, North American index fossils, vol. 1, fig. 1064*d* (= *Turritella mortoni* Conrad).

Turritella mortoni Conrad. HARRIS, *1899*, *ex parte*, Bull. Am. Paleontology, vol. 3, no. 11, pp. 74, 75, pl. 10, fig. 4.—HARRIS, *1900*, Louisiana Geol. Survey, Rept. for 1899 (Special Rept. 6), p. 308, pl. 55, fig. 4.—VEATCH, *1906*, *ex parte*, U. S. Geol. Survey, Prof. Paper 46, pl. 14, fig. 5 (Not pl. 14, fig. 5*a* = *Turritella mortoni* Conrad).—GUILLAUME, *1924*, *ex parte*, Soc. géol. France, Bull., ser. 4, vol. 24, p. 289.—COOKE, *1926*, Alabama, Geol. Survey, Special Rept. 14, pp. 259, 261, 264, pl. 94, fig. 2. Not *Turritella mortoni* CONRAD, *1830*.

Turritella (*Haustator*) *mortoni* Conrad. COSSMANN, *1912*, *ex parte*, Essais de paléoconchologie comparée, pp. 115, 118, pl. 7, fig. 12.

Shell large, robust. Spire high, rather abruptly tapering. Whorls numerous, much wider than high, narrow posteriorly, basally carinated in adult stages. Sutures linear and indistinct apically, becoming more deeply impressed with the growth of the shell. Apical whorls marked by two distinct revolving cords set close together on the anterior half of the whorl; a smaller cord situated near the posterior suture; finer revolving threads appearing early in the growth of the shell, variously placed with respect to the primary cords; anterior primary lira becoming relatively stronger than the rest of the sculpture until on the ninth or tenth whorl it forms a distinct carina, which becomes progressively more prominent with the growth of the shell; the other two primary lirae becoming less distinct in the adult stages until on the body whorl they are subequal to the numerous fine revolving secondary lines; a revolving cord appearing on the under side of the basal carina on the tenth whorl with another commonly added with each volution so that, on the largest specimens observed, the number reaches four or five; base of body whorl marked by 10 or 12 fine revolving lines. Incrementals distinct; deeply flexed at about the posterior third of the whorl and then strongly reflexed below the basal carina. Parietal callus large, distinct. Aperture subrounded, obscurely undulated medially on the outer lip by the strong carina.

Dimensions: Not given by Harris for the holotype. Figured specimen, height, 65.0 mm; greatest diameter, 23.0 mm.

Type material: A holotype in the collection of the Paleontological Research Institution, Ithaca, New York. Figured specimen, U. S. Nat. Mus. no. 497992.

Type locality: (according to Harris) Bells Landing, Alabama River, Monroe County, Alabama. The figured specimen is a topotype. Wilcox group, Tuscahoma sand.

Turritella mortoni postmortoni differs from typical *T. mortoni* of the Maryland and Virginia Aquia formation in its smaller size, more slender whorl, more anterior and acutely angulated carina, and less distinct secondary sculpture. These differences seem sufficient to justify its retention as a subspecies.

Harris (1894a, p. 302) has recorded *Turritella mortoni postmortoni* from the Aquia formation of Virginia, and Clark and Martin (1901, pp. 147, 148, pl. 26, fig. 5) refer material from Maryland to this subspecies. These smaller, more sharply carinated forms that are found in association with typical *Turritella mortoni*, however, are younger stages of that species and are not referable to the Alabama subspecies.

Turritella mortoni postmortoni is found throughout the Nanafalia and Tuscahoma formations and has been recovered as far west as the Sabine Uplift region of East Texas, where it is recorded from deposits of Tuscahoma age. The mention in the litera-

ture of *Turritella mortoni* from the Sabine region are references to the subspecies *postmortoni*. Typical *T. mortoni* is restricted to the Aquia formation of Maryland and Virginia.

The subspecies has been recorded from Georgia only from strata of Nanafalia age. Stephenson and Veatch's (1911, 1915) mention of "*Turritella mortoni*" from the Wilcox probably refers to the subspecies *postmortoni*. No specimens of this form from Georgia, however, can be found in the collections of the National Museum.

Distribution.—Wilcox group, Nanafalia formation. ALABAMA, *Wilcox County:* U. S. G. S. sta. 10766, new highway to Camden, 9.7 miles west of Pineapple. *Marengo County:* U. S. G. S. stas. 271 and 5641, Nanafalia Bluff, Tombigbee River. *Pike County:* U. S. G. S. sta. 10765, Three-Notch road, ¼ mile northeast of Henderson, middle of sec. 17, T. 8 N., R. 20 E.

Wilcox group, Tuscahoma sand. ALABAMA, *Choctaw County:* U. S. G. S. sta. 5472, Tuscahoma landing, Tombigbee River. *Dale County:* U. S. G. S. sta. 10769, Becks Mill, Pea River, 10 miles from Brundidge, sec. 7, T. 7 N. R. 23 E. *Wilcox County:* U. S. G. S. stas. 260, 2669, 3098, 5593, 5594 and 5595, Bells landing, Alabama River; U. S. G. S. stas. 2670, 3117, 3118, 3604 and 5642 and U. S. Nat. Mus. no. 90971, Greggs landing, Alabama River; U. S. G. S. sta. 10779,[4] Descent to Lower Peachtree Ferry, Alabama River; U. S. G. S. sta. 5602, Lower Peachtree Ferry, 2nd fossil horizon, 60 feet from top, 80 feet from bottom of bluff, Alabama River; U. S. G. S. sta. 5603, Lower Peachtree Ferry, upper fossil bed, 20 feet from top of bluff, Alabama River; U. S. G. S. sta. 3120, Peebles Landing, 1 mile below Lower Peachtree Ferry, Alabama River; U. S. G. S. stas. 3121, 7480, and 10782, Yellow Bluff, Alabama River. TEXAS, *Sabine County:* U. S. G. S. sta. 10743, Pendleton, Sabine River; U. S. G. S. sta. 11099, Sabine River, ¼ mile above Pendleton Ferry.

TURRITELLA ALABAMIENSIS Whitfield
Plate 32, figure 21

Turritella alabamiensis WHITFIELD, *1865*, Am. Jour. Conchology, vol. 1, p. 267.—DEGREGORIO, *1890*, Faune éocénique de l'Alabama, p. 128.—ALDRICH, *1894*, Alabama Geol. Survey, Rept. for 1894, pp. 239, 246, pl. 13, fig. 2.—COSSMANN, *1894*, Notes comp. sur la faune éocénique de l'Alabama, p. 29.—?HARRIS, *1894*, Arkansas Geol. Survey, Ann. Rept. for 1892, vol. 2, pp. 30, 48.—HARRIS, *1896*, Bull. Am. Paleontology, vol. 1, no. 4, pp. 14, 17, 30, 33–35, 109, pl. 11, fig. 6.—GARDNER, *1935*, Univ. Texas, Bull. 3301, pp. 284, 285.—PALMER, *1937*, Bull. Am. Paleontology, vol. 7, no. 32, p. 202.

Turritella (*Haustator*) *alabamiensis* COSSMANN, *1912*, Essais de paléoconchologie comparée, vol. 9, p. 118.

Turritella alabamiensis var. *prealaba* Conrad. KENNEDY, *1895*, Acad. Nat. Sci. Philadelphia, Proc. for 1895, p. 146 (nomen nudum; this species was never described nor the name mentioned by Conrad).

Turritella mortoni Conrad. SMITH and JOHNSON, *1887, ex parte*, U. S. Geol. Survey Bull 43, p. 59.

Spire slender, high, gently tapering. Whorls numerous, slightly concave in profile, carinated at the base in the older stages but not overhanging the sutures, which are linear, distinct and fairly deeply impressed. Apical whorls marked by three subequal, inconspicuous cords; intercalaries introduced on the third and fourth whorls, obscure at first, but gradually strengthening until on the later whorls they are the same size as the three primary cords and indistinguishable from them; revolving cords numerous on the adult whorls, equally spaced. Incremental striae strongly marked, deeply flexed just posterior to the middle of the whorl and meeting the anterior suture just a little behind their intersection with the posterior suture. No perfect aperture observed.

Dimensions: Cotype, height, 35.0 mm; greatest diameter, 10.0 mm.

Type material: A number of cotypes in the collection of the Walker Museum of the University of Chicago, formerly in the collection of James Hall.

Type locality: "Nine miles below Prairie Bluff, Alabama" (Whitfield, 1865). Little confidence can be placed in the localities cited by Whitfield in this paper. In regard to these localities Aldrich (1887, p. 81) writes

> All the localities given in this paper of Prof. Whitfield's seem to be mixed, judging by my own collections, and as Hale considered the Tertiary much thinner than it turns out to be, he may

[4] This is the material referred by Cooke, C. W., Geol. Survey Alabama, Spec. Rept. 14, p. 264, to *Turritella mortoni*, var.

have mistaken different beds and misplaced the fossils.

"Nine miles below Prairie Bluff" falls a little beyond Matthews Landing, but the cotype that was kindly loaned me by the Walker Museum of the University of Chicago is identical in every way with the numerous specimens in the collections of the U. S. National Museum and the Aldrich collection of the Johns Hopkins University from Matthews Landing, agreeing in state of preservation, and even in the similarity of the adherent pieces of matrix.

This species most closely resembles *Turritella aldrichi*, a contemporaneous form from Alabama, differing from it in the lack of a subsutural collar and the presence of a basal carina on the adult whorls. These characters are sometimes obscure, however, particularly in weathered specimens, rendering the separation of the two species difficult.

Aldrich, in 1894, figured a specimen of this species from the lower Midway of Prairie Creek, Wilcox County, Alabama. The specimen figured by Aldrich is a somewhat decorticated individual, similar to most of the material from the lower Midway, and it does not show the numerous revolving lines that are so perfectly preserved in the Naheola specimens. A few well preserved specimens from the lower Midway, however, do exhibit traces of this sculpture, and these are not specifically separable from the upper Midway material.

Veatch and Stephenson (1911, p. 224), following Vaughan's determination, list *Turritella alabamiensis* from Wall's Crossing, 4½ miles northwest of Ellaville, Schley County, Georgia. These specimens cannot be found in any of the collections of the U. S. National Museum, but material from 5 miles west of Ellaville is referred to *Turritella aldrichi*.

Harris (1894, p. 30) has recorded *Turritella alabamiensis* from U. S. G. S. sta. 2433, about 1½ miles northeast of Alexander, Pulaski County, Arkansas (NW ¼ SE ¼ sec. 8, T. 1 S., R. 13 W.), but this material is so poorly preserved and so fragmentary that specific determination is impossible. The specimens are somewhat basally carinate, but whether they should be assigned to *T. alabamiensis* or to some other member of the *T. mortoni* group remains in doubt.

Kennedy (1895, pp. 146, 148), Plummer (1933, pp. 547, 551), and Gardner (1935, pp. 284, 285) have all recorded *Turritella alabamiensis*, or closely related, specifically indeterminate forms from the Midway of Texas. Most of Miss Gardner's material is poorly preserved, but it does seem identical, and so it is tentatively placed here as conspecific with the *T. alabamiensis* of the Alabama Midway. I have not seen Kennedy's or Plummer's material. The material from Kaufman County, Texas, identified by Harris in 1894 as *T. mortoni* is in the collections of the U. S. National Museum and proves to be *Turritella alabamiensis*.

Turritella alabamiensis is restricted to the Midway group, but it is found in both the lower and upper divisions. The type material of Whitfield has never before been figured.

Distribution.—Midway group, Clayton formation. ALABAMA, *Wilcox County:* U. S. G. S. sta. 264, Prairie Creek; U. S. G. S. stas. 281 and 284, Prairie Creek and Allenton, Pine Barren section; U. S. G. S. sta. 283, Black Creek branch of Prairie Creek; U. S. G. S. sta. 3102, "Black Bluff" beds, surface of prairies at Graveyard Hill, 3 miles west of Oak Hill Postoffice.

Midway group, Kincaid formation. TEXAS, *Bastrop County:* U. S. G. S. sta. 11909, Cedar Creek, about 4 miles (airline) southeast of Williams' store, upper indurated ledge; U. S. G. S. sta. 11911, roadside gully, ½ mile east of Williams' store, Austin quadrangle. *Caldwell County:* U. S. G. S. sta. 11707, second greensand,[5] 5½ miles due north of Lockhart on E. A. Moser farm (Isaac Jackson survey) about ½ mile northwest of Simms Oil Co. derrick. *Falls County:* U. S. G. S. sta. 11932, in roadside gully, ¼ mile northwest of Stranger School. *Hunt County:* U. S. G. S. sta. 10264, some 14 miles southeast of Greenville, on the Lone Oak pike, about 50 yards from the pike on the east side of the Cowleech fork just as the road is climbing the hill on the northeast side of the pike. *Kaufman County:* U. S. G. S. sta. 2440, 4 miles northeast of

[5] For a detailed account of the Midway stratigraphy of Texas see GARDNER, JULIA, *1935* Univ. Texas, Bull. 3301.

Kemp; U. S. G. S. sta. 11665, Water Hill, 5 miles northeast of Kemp.

Midway group, Naheola formation. ALABAMA, *Wilcox County:* U. S. G. S. stas. 2671, 3116 and 5596 and U. S. Nat. Mus. no. 90962, Matthews Landing on the Alabama River.

TURRITELLA LEVICUNEA Harris

Turritella mortoni var. *levicunea* HARRIS, *1896*, Bull. Am. Paleontology, vol. 1, no. 4, p. 110, pl. 11, fig. 9.

Not *Turritella levicunea* Harris. PLUMMER, *1933*, Univ. Texas, Bull. 3232, p. 815, pl. 10, figs. 4, 4a (= *Turritella hilli* Gardner).

Shell large; spire high, abruptly tapering. Whorls numerous, straight-sided or slightly concave in profile; equidimensional in youth, much wider than high in the adult stages. Apical sculpture consisting of two not very prominent revolving cords on each whorl, one near the posterior and one near the anterior suture, the cords being much nearer the sutures than they are to each other; many intercalaries introduced early between the two revolving cords and between them and the sutures; the two primary cords becoming less prominent on the adult whorls and the intercalaries relatively stronger, until on the last two or three whorls the sculpture consists of very fine revolving lines, regularly spaced and subequal in strength. Whorls basally carinated, the carina slightly overhanging the linear and indistinct suture; carination most evident on the adult whorls, becoming relatively stronger with the growth of the shell. Growth lines strongly reflexed as in the other members of the *Turritella mortoni* group. Aperture unknown.

Dimensions: Not given by Harris, but as indicated by the figure, the holotype is 36.0 mm in length. Figured specimen, height, 38.0 mm; greatest diameter, 20.0 mm. (Both the figured specimen, and the holotype, are broken at the aperture and the apex.)

Type material: A holotype in the collections of the Paleontological Research Institution, Ithaca, New York. Specimen: U. S. Nat. Mus. no. 495150.

Type locality: Holotype, "Alabama: Matthews Landing: Dale's Branch. Georgia: Ft. Gaines" (Harris, 1896). Midway group, Clayton formation.

The carina that distinguishes the members of the *Turritella mortoni* group is present in this species, but it is more basally located on the whorl, and is much less prominent than in *T. mortoni*, s. s. The rapidly ascending spire gives the species a general resemblance to the genus *Mesalia*, but the angulation of the whorls and the strongly reflexed growth lines indicate a closer relationship to *Turritella*.

The specimens that Plummer, in 1933, figured under the name, *T. levicunea* Harris, were described by Miss Gardner two years later as a new species, *Turritella hilli*. This Texas form seems much closer to *T. mortoni* and its southern analogue, *T. postmortoni* of the Wilcox fauna, than it does to *T. levicunea*.

Although Harris records the species from the lower Midway Clayton formation of Dale's Branch, Alabama and Fort Gaines, Georgia as well as the upper Midway Naheola formation of Matthews Landing, Alabama, *Turritella levicunea* is present only in those collections of the U. S. National Museum from the Clayton formation at Prairie Creek, Wilcox County, Alabama.

TURRITELLA HILLI Gardner

Turritella levicunea Harris. PLUMMER, *1933*, Univ. Texas, Bull. 3232, p. 815, pl. 10, figs. 4, 4a.

Turritella hilli GARDNER, *1935*, Univ. Texas, Bull. 3301, pp. 292–293, pl. 25, figs. 4–6.

Shell rather small for the genus, not very heavy. Apical angle between 20° and 25°, the early whorls evenly trapezoidal, the later marked by a broad and shallow medial depression and with an increasingly prominent overhang directly behind the anterior suture. Early apical whorls sculptured with 2 strong simple spirals on the anterior half of the whorls, another of almost equal strength a little behind the middle and except on the very earliest whorls, a finer spiral directly in front of the posterior suture. Intercalaries introduced between the primary spirals and between the spirals and the suture lines, the anterior of the primary spirals following the peripheral keel of the later whorls. Spirals on adult whorls irregular in size and spacing; the coarsest spirals, 1 to 4 in number, at the periphery and directly in front of or behind it; those on the posterior fourth of the whorl obliterated on the latest adult volutions by the overriding growth lines; adult spirals tending to be wavy and dissected by strong and crinkled incrementals bent backward in a broad and symmetrical U. No perfect apertures observed.

Dimensions.—Height of holotype (incomplete), 36.0 mm; diameter of holotype, 13.0 mm.

Holotype and 2 paratypes.—U. S. Nat. Mus. no. 373054.

Type locality.—U. S. G. S. sta. 10526, Colorado River, 4± miles below Webberville, Bastrop County. Kincaid formation of the Midway group.

The molds are loosely wound, and the whorls rounded in the juvenile stages though trapezoidal in the adult.

The shells are usually fragile and although fragments are abundant, no adequate type material has been collected. The holotype by no means reaches the maximum dimensions attained by some of the more imperfect individuals. (Gardner, 1935.)

Turritella hilli is known only from the Midway of Texas and is restricted to the upper part of the Kincaid formation.

Plummer (1933) figured a specimen of this species from three-fourths of a mile downstream from the mouth of Dry Creek on the right bank of the Colorado River, Bastrop County, Texas, under the name of *T. levicunea* Harris. *T. hilli* differs from the Alabama species of Harris in the smaller apical angle, and the suture in *T. hilli* does not follow the keel as it does in *T. levicunea*, but lies a little in front of it. The Texas form more closely resembles the Wilcox species, *T. postmortoni*.

Distribution.—Midway group, Kincaid formation. TEXAS, *Bastrop County:* U. S. G. S. sta. 10526, Colorado River, ½ mile above the mouth of Dry Creek, 3½ to 4 miles downstream from Webberville; U. S. G. S. sta. 11696, Colorado River, 1½ miles below the Travis-Bastrop County line; U. S. G. S. sta. 12112, Colorado River, one-half to three-fourths of a mile above the mouth of Dry Creek (lower and upper end of outcrop).

TURRITELLA GILBERTI Bowles, n. sp.

Plate 32, figure 16

Turritella carinata Lea. ALDRICH, *1894*, Alabama Geol. Survey, Rept. for 1894, pp. 235, 236.—BRANTLY, *1920*, Alabama Geol. Survey Bull. 22, p. 156.

Turritella lineata Lea. SMITH, LANGDON, and JOHNSON, *1894*, Alabama Geol. Survey, Rept. for 1894, p. 156.

Turritella clevelandia Harris. HARRIS, *1897*, Bull. Am. Paleontology, vol. 2, no. 9, p. 32. Not HARRIS, *1894*.

Turritella clevelandia Harris, var. HARRIS, *1899*, Bull. Am. Paleontology, vol. 3, no. 11, p. 74, pl. 10, fig. 2.

Shell small. Spire acute, gently tapering. Whorls numerous, straight-sided in the apical stages, slightly carinated basally in the adolescent and adult. Sutures distinct and very deeply impressed; linear, not channelled; not overhung by the whorls and giving a suggestion of loose coiling. Apical whorls marked by three distinct, subequal revolving cords, equidistant from each other, the anterior lira slightly closer to the anterior suture than the posterior lira is to the posterior suture; a secondary line appearing between the two anterior primary lirae on the sixth whorl, and another between the two posterior on the seventh; other accessory lines constantly added so that on the body whorl of the holotype there are eight lirations in addition to the three primary cords, some of the secondary lines approaching the primary lirae in size; whorls sharply undercut and constricted toward the suture immediately below the anterior primary lira, forming a slight carination, most evident on the adult stages. Incrementals deeply arcuate, the maximum retraction being reached at about the posterior third of the whorl, recurving slightly below the carination. Parietal wash inconspicuous. Aperture rhomboidal, its longest dimension parallelling the axis of the spire; outer lip very thin and fragile, not observed entire.

Dimensions: Holotype, height, 35.5 mm; greatest diameter, 10.0 mm.

Type material: A holotype, U. S. Nat. Mus. no. 494993.

Type locality: U. S. G. S. sta. 2667, Woods Bluff, Alabama River, Clarke County, Alabama. Wilcox group, Bashi formation.

Turritella gilberti is the only species recognized in the upper Wilcox formations of the Gulf Province. The deeply incised sutures, with the whorls constricted both before and behind them, distinguish this species from any other in the lower Eocene. The closest analogue seems to be *Turritella potomacensis* Clark and Martin from the Nanjemoy formation of Maryland, but in the northern species the whorls are less rhomboidal and the sutures less deeply incised.

There is a strong resemblance between *Turritella gilberti* and the Jackson species *Turritella clevelandia* Harris, but the younger species is even more loosely coiled

and may be readily distinguished. Harris (1899, p. 74) first pointed out the distinctions between *T. gilberti* and the Jackson species. Earlier, Aldrich had referred the Woods Bluff form to *Turritella carinata* Lea.

Turritella gilberti is extremely prolific at Woods Bluff and one of the most abundant species in the extensive Bashi collections of the U. S. National Museum.

Distribution.—Wilcox group, Bashi formation. ALABAMA, *Clarke County:* U. S. G. S. stas. 262, 2667, 3099, 3100, 5470, 6205, 6206, 6207, and 7482 and U. S. Nat. Mus. no. 90978, Woods Bluff, Alabama River; U. S. G. S. sta. 7153, headwaters of Beaver Creek about ¼ mile east of Choctaw Corners, lower bed; U. S. G. S. sta. 7154, same locality as 7153, upper bed; U. S. G. S. sta. 7155, gully on land of Henry Jackson, near middle of sec. 7, T 11 N., R. 2 E., about 3 miles west of Choctaw Corners. *Choctaw County:* U. S. G. S. sta. 10768, roadside, ½ mile west of Butler. *Coffee County:* U. S. G. S. stas. 10012 and 10781, near mouth of branch flowing into Pea River at Churchwells Bridge, 5½ miles south of Elba; U. S. G. S. stas. 10013 and 10780, Pea River at power plant, 4 miles below Elba. *Dale County:* U. S. G. S. sta. 11093, hillside at swimming pool, near Atlantic Coast Line R. R. station, Ozark. MISSISSIPPI, *Lauderdale County:* U. S. G. S. sta. 2105, McKays marl bed, Souwashee Creek, 2 miles south of Meridian; U. S. G. S. stas. 7267*a*, 7267*b*, 7734, and 10055, cut on Memphis and Meridian R. R. 300 yards south of Seymours Hill, 1½ miles south of Meridian.

TURRITELLA DUMBLEI Harris
Plate 32, figures 9, 19

Turritella dumblei HARRIS, *1895*, Acad. Nat. Sci. Philadelphia, Proc. for 1895, p. 81, pl. 9, fig. 7.—KENNEDY, *1895*, Acad. Nat. Sci. Philadelphia, Proc. for 1895, pp. 123, 124, 127, 128, 129.—PALMER, *1937*, Bull. Am. Paleontology, vol. 7, no. 32, p. 202, pl. 26, figs. 10, 11, 15.

Shell medium-sized for the genus. Spire high, acute, gently tapering. Whorls slightly convex when young, straight-sided in adolescence and, when adult, slightly carinated basally and markedly convex. Sutures linear and distinct between the apical whorls, more pronounced and deeply impressed between the adult whorls. Apical whorls marked by three subequal prominant revolving lirae, equidistant from each other and symmetrically placed on the whorl; anterior lira rapidly increasing in size, forming a distinct basal swelling of the whorl in adolescence, with a corresponding swelling just in front of the suture arising simultaneously, which is deeply impressed on this raised area; anterior carination fairly pronounced on the adult whorls, but rounded and not sharp as in *Turritella mortoni;* subsutural swelling diminishing with the growth of the shell, almost indistinguishable on the body whorl; under side of carina marked by numerous fine, revolving threads; fine secondary lirae arising in adolescence posterior to the strong carina, rapidly assuming prominence comparable to that of the two primary lirae until on the body whorl there are six or seven subequal cords, augmented by numerous fine but very distinct filaments covering the entire whorl, including the basal carination. Incrementals distinct but not strongly marked, not deeply arcuate, the maximum curvature attained at about the median of the whorl, sharply recurved at the anterior suture; frequently sharply cutting the spiral sculpture and beading the less prominent lirae at their intersections with them. Aperture not preserved entire.

Dimensions: Holotype (as indicated by Harris), height, 30.0 mm; greatest diameter, 11.0 mm (the holotype is broken both at the aperture and the apex). Figured specimens: height, 26.5 mm; greatest diameter, 7.5 mm (broken slightly at the tip). Height, 16.5 mm; greatest diameter, 8.0 mm (only four adult whorls preserved).

Type material: A holotype in the collection of the Texas State Museum, Austin, Texas, probably now lost, according to Mrs. Palmer (1937, p. 202). Two figured specimens, U. S. Nat. Mus. no. 498003.

Type locality: (as given by Harris) Moseley's Ferry, Brazos River, Brazos County, Texas. Figured specimens, U. S. G. S. sta. 13231, 1 mile east of Jourdanton on the Pleasanton Road, Atascosa County, Texas. Claiborne group, Cook Mountain formation.

Turritella dumblei is confined to the Cook Mountain formation and has not been recorded outside of Texas. It is not abundant, but it is well characterized and easily identi-

fied. The rounded basal carination distinguishes this species from any other in the Cook Mountain, and the only form that closely resembles it is the Reklaw subspecies *Turritella dumblei turneri* Plummer. This stratigraphically lower subspecies has a sharper basal carina than typical *T. dumblei*, and the revolving lirae are more prominent.

Distribution.—Claiborne group, Cook Mountain formation. TEXAS, *Atascosa County:* U. S. G. S. sta. 13231, 1 mile east of Jourdanton on the Pleasanton road: U. S. G. S. sta. 8870, ¼ mile northwest of Jourdanton. *Brazos County:* U. S. G. S. stas. 4786 and 10343, Moseley's Ferry on the Brazos River near Stone City; U. S. G. S. sta. 14210, 9.8 miles from the main corner of Bryan on highway 21, 50 feet to 300 feet upstream from the highway crossing. Little Brazos River; lower part of section. *Robertson County:* U. S. G. S. sta. 2048, Montgomery's well, ½ mile east of Wheelock.

TURRITELLA DUMBLEI TURNERI Plummer

Turrietella turneri PLUMMER, *1933*, Univ. Texas, Bull. 3232, p. 815, pl. 10, figs. 10, 10a.

Turritella mortoni turneri PALMER, *1937*, Bull. Am. Paleontology, vol. 7, no. 32, p. 195, pl. 23, figs. 4, 5 (only) (Not pl. 23, figs. 3, 7 = *Turritella carinata palmerae* n. sp.).

Apical angle: 17.5°; sculpture: 5 unequal spirals, anterior spiral largest; whorl shape: strongly convex, posterior whorl slope slightly longer than anterior.

Type locality: old copper prospect 4½ miles northeast of Harwood, Caldwell County; Reklaw formation. (Plummer, 1933.)

Turritella dumblei turneri differs from typical *T. dumblei* in its sharper basal carina and more prominent revolving lirae. The differences are slight, but they seem to have a stratigraphic significance and so the name of Plummer is retained. The subspecies has been recorded from the Reklaw member of the Mt. Selman formation in Texas. Mrs. Palmer referred some of her Lisbon material to *Turritella turneri*, but the Lisbon form is quite distinct from the Texas species, and much more closely allied to the later *Turritella carinata* Lea of the Moodys marl of Alabama.

Distribution.—Claiborne group, Mt. Selman formation. TEXAS, *Bastrop County:* U. S. G. S. sta. 14212, "Balaam Jackson's farm," across the Colorado River from Upton Crossroads.

TURRITELLA CARINATA Lea
Plate 33, figure 13

Turritella carinata LEA, *1833*, Contributions to geology, pp. 129, 130, pl. 4, fig. 120.—DANA, *1863*, Manual of geology, p. 517, fig. 802—DEGREGORIO, *1890*, Faune éocénique de l'Alabama, p. 122, pl. 11, figs. 3–6, 9.—DOUVILLÉ, *1904*, in DEMORGAN, Mission scientifique en Perse, vol. 3, pt. 4, p. 336.—PALMER, *1937*, Bull. Am. Paleontology, vol. 7, no. 32, p. 189. pl. 24, figs. 5, 6, 8, 9, 12, pl. 82, fig. 1. Not H. C. LEA, Am. Jour. Sci., vol. 40, p. 96, pl. 1, fig. 10 (= *Turritella apita* DeGregorio).

Turritella mortoni CONRAD, *1835*, Fossil shells (republication), pl. 15, fig. 11. Not CONRAD, *1830*.

Turritella monilifera H. C. LEA, *1840*, Am. Jour. Sci., vol. 40, p. 97, pl. 1, fig. 11. Not ADAMS and REEVE, *1850*.

Turritella gracilis H. C. LEA, *1840*, Am. Jour. Sci., vol. 40, p. 97, pl. 1, fig. 12.—DEGREGORIO, *1890*, Faune éocénique de l'Alabama, p. 127, pl. 11, fig. 32.

Turritella ghigna DEGREGORIO, *1890*, Faune éocénique de l'Alabama, p. 125, pl. 11, fig. 19. —PALMER, *1937*, Bull. Am. Paleontology, vol. 7, no. 32, p. 191, pl. 24, figs. 2, 4, 11, 13, 15; pl. 83, fig. 1.

Turritella litripa DEGREGORIO, *1890*, Faune éocénique de l'Alabama, p. 125, pl. 11, fig. 20.

Turritella carinifera Deshayes var. *claibornensis* DEGREGORIO, *1890*, Faune éocénique de l'Alabama, p. 126, pl. 11, figs. 24, 33.

Turritella eterina DEGREGORIO, *1890*, Faune éocénique de l'Alabama, p. 126, pl. 11, figs. 34–36.

Turritella hybrida Deshayes. DEGREGORIO, *1890*, Faune éocénique de l'Alabama, p. 126, pl. 11, fig. 23.

Turritella mela DEGREGORIO, *1890*, Faune éocénique de l'Alabama, p. 127, pl. 11, fig. 40.

Spire high, gradually tapering; whorls numerous, wider than high, straight-sided in youth, becoming slightly concave and strongly carinate basally when adult. Sutures narrow, deeply impressed, particularly between the adult whorls. Apical whorls marked by three indistinct spiral lirae, equidimensional and symmetrically placed on the whorl; accessory spiral lirae added with the growth of the shell, their number and position on the whorls varying greatly; sculpture most prominent in adolescence, becoming much less marked on the adult whorls; anterior primary lira developing strongly in adolescence, forming a marked basal carination on the adult whorls; base of body whorl sculptured by a few indistinct revolving threads. Incrementals distinct but not prominent, strongly arcuate, attaining the maximum of their curvature a

little behind the median of the whorl. Aperture not preserved complete.

Dimensions: (not given by Lea for the holotype). Figured specimen: height, 39.5 mm; greatest diameter, 11.5 mm.

Type material: A holotype (no. 5661) and six paratypes (nos. 5662–5667) in the collection of the Philadelphia Academy of Natural Sciences. Figured specimen: U. S. Nat. Mus. no. 497995.

Type locality: Claiborne Bluff, Alabama River, Monroe County, Alabama. The figured specimen is a topotype. Jackson group, Moodys marl.

Turritella carinata is the most variable species in the East American Eocene. The specimen selected by Lea as his holotype is a typical adult form with the basal carination well developed, but there are almost infinite variations within the species. Some of the extreme individuals have straight-sided whorls with little indication of a carination; the revolving lirae on some specimens are distinctly beaded at their intersections with the growth lines; the adult whorls sometimes show as few as two revolving lirae, sometimes as many as six. Vaughan[6] has estimated that there are 2560 possible distinct variations of *T. carinata*, considering all the combinations of whorl profile, apical angle, and sculpture. H. C. Lea and DeGregorio have given a number of names to variants from the typical, but these names are all included here in the synonymy. Mrs. Palmer (1937, p. 191) utilized the name *Turritella ghigna* DeGregorio for the extreme individuals in which the basal carination is either much reduced or absent. This is merely an end member, however, in a continuous series of variants, and since the differences are neither constant nor have any stratigraphic implication, the separation is not followed. Regardless of the variation of the adult whorls in *Turritella carinata*, the apical whorls show identical characters, being straight-sided with no sign of basal carination and bearing three subequal, more or less indistinct, revolving lirae.

The nearest relative of *T. carinata* is the subspecies *palmerae*, n. subsp., described from the Claiborne beds of South Carolina, Alabama and Mississippi. The subspecies differs from the typical form in its more constant and more rounded basal carination, and much more distinct sculpture, particularly on the adult whorls. The apical whorls are marked by the same tricostate ribbing, but the lirae are stronger and persist onto the adolescent and adult whorls much more consistently. The differences would probably not have been recognized taxonomically were it not for their stratigraphic significance.

Distribution.—Jackson group, Moodys marl. ALABAMA, *Monroe County:* U. S. G. S. stas. 263, 2391 and 2867, Claiborne Bluff, Alabama River.

[6] Vaughan, T. W., Oral communication, 1938.

TURRITELLA CARINATA PALMERAE
Bowles, n. subsp.
Plate 33, figure 12

Turritella mortoni turneri Plummer. PALMER, *1937, ex parte*, Bull. Am. Paleontology, vol. 7, no. 32, p. 195, pl. 23, figs. 3, 7.

Turritella carinata palmerae differs from typical *T. carinata* in its rounded and less variable basal carination. The apical sculpture of the two forms is identical, but on the subspecies *palmerae* the revolving lirae persist onto the adult whorls with much greater prominence than they do on the typical form.

Dimensions: Holotype; height, 29.0 mm; greatest diameter, 9.5 mm.

Type material: A figured holotype: U. S. Nat. Mus. no. 497997.

Type locality: U. S. G. S. sta. 13433, Lisbon Landing, Alabama River, bed no. 4 of Cooke section. Lisbon formation.

As Mrs. Palmer first noted this form in the Lisbon of Alabama, I take great pleasure in naming the subspecies in her honor. She assigned the Alabama forms to Dr. Plummer's *T. turneri*, but this Texas species has more numerous revolving lirae, a more rounded basal carination and is a smaller form.

Turritella carinata palmerae is confined to the Claiborne of the eastern Gulf region, being recorded from South Carolina, Alabama and Mississippi.

Distribution.—Claiborne group, McBean formation. SOUTH CAROLINA, *Aiken County:* U. S. G. S. sta. 4603, Hixon Bridge, Tinker's Creek, public road 200 feet east of bridge,

12½ miles west of Williston. *Orangeburg County:* U. S. G. S. sta. 4580, Pooser's Hill, 5.1 miles north of Orangeburg Courthouse; U. S. G. S. sta. 2009, Caw Caw Swamp, 2 miles west of Orangeburg.

Claiborne group, Lisbon formation. ALABAMA, *Monroe County:* U. S. G. S. stas. 5511 and 6086, Lisbon landing, Alabama River; U. S. G. S. sta. 13431, Lisbon Landing, Alabama River, bed 7 of Cooke section; U. S. G. S. sta. 13433, Lisbon Landing, bed 4 of Cooke section. MISSISSIPPI, *Clarke County:* U. S. G. S. sta: 131 and 3092, Wautubbee Hills, 4 miles west of Enterprise; U. S. G. S. sta. 2616, Wautubbee Hills, 4 miles south of the Northeastern depot in Enterprise; U. S. G. S. sta. 2622, Old Enterprise road, Johnson's farm, 8 miles south of Hickory and 12 miles northwest of Enterprise; U. S. G. S. sta. 2623, Wautubbee Hills, Johns farm, south of creek and 9½ miles south of Hickory. *Newton County:* U. S. G. S. sta. 2624, old Enterprise road, going down the hill to the Pottoxchitto Swamp, 2 miles southeast of Hickory; U. S. G. S. sta. 14058, railroad cut at Indian Mound, 3¼ miles east of Newton.

Claiborne group, St. Maurice formation. LOUISIANA, *Winn Parish:* U. S. G. S. sta. 2005, Mouth of Saline Bayou, St. Maurice.

TURRITELLA ALVEATA Conrad
Plate 32, figure 1

Turritella alveata Conrad, WAILES, *1854*, Agriculture and Geology of Mississippi, pl. 17, fig. 7.—CONRAD, *1855*, Acad. Nat. Sci. Philadelphia, Proc., 1st ser., vol. 7, p. 263.—HARRIS, *1894*, Geol. Survey Arkansas, Ann. Rept. for 1892. pt. 2, pp. 120, 169, 181.

Shell small. Spire high, gently tapering. Whorls straight-sided or slightly convex, sharply constricted at the linear, deeply impressed sutures. Apical whorls marked by three subequal revolving lirae, equidistant from each other and symmetrically placed on the whorl; a fourth lira arising on the sixth whorl posterior to the three primaries, a fifth appearing on the seventh whorl between the two anterior primaries and a sixth appearing on the eighth whorl between the second and third posterior primaries; secondary lines rapidly becoming more prominent until on the adult whorls they are equal in size to the primaries and indistinguishable from them; adult whorls marked by six (Conrad described five on the holotype, and some of the specimens exhibit seven, but six is the most usual number) subequal revolving lirae equidistant from each other, separated from the anterior suture by a wide, channelled, smooth area with no spiral sculpture. Incrementals distinct but not prominent, deeply arcuate with the maximum flexure attained a little behind the median of the whorl, very slightly reflexed just behind the anterior suture. Complete aperture not observed.

Dimensions: Not given by Conrad for the holotype. Figured specimen (an incomplete individual broken at the aperture), height, 36.5 mm; greatest diameter, 9.0 mm.

Type material: A lectotype and a paratype, Philadelphia Academy of Natural Science no. 13213. Figured specimen, U. S. Nat. Mus. no. 498001.

Type locality: (According to Conrad) Jackson, Mississippi. The figured specimen is a topotype.

Turritella alveata differs from *Turritella perdita* Conrad, of the Jackson horizon, with which it is associated in many of the collections, by the much smaller apical angle, less angulated and more evenly sculptured whorls, and the much less deeply marked sutures. *T. alveata* is confined to the Jackson formation and has been recorded from Mississippi, Louisiana and Arkansas.

The species was figured by Conrad in Wailes' report of 1854, but the description was not published until the following year. The figured specimen is one of a lot sent to the National Museum by Professor Wailes, who also collected Conrad's type material.

Distribution.—Jackson group. Moodys marl. MISSISSIPPI, *Hinds County:* U. S. G. S. stas. 54 and 58, Greens marl bed, Jackson; U. S. G. S. stas. 60, 63, 3735, 6462, and 10377, Moodys Branch, Jackson; U. S. G. S. stas. 64, 3665, and 13398, Jackson marl bed, Jackson; U. S. G. S. sta. 734, South of pump house, Jackson; U. S. G. S. sta. 3746, Moodys Branch, below second bridge, Jackson; U. S. G. S. sta. 4250, Moodys Branch, first bluff below first bridge, east of the Institute for the blind, Jackson; U. S. Nat. Mus. no. 1532, Jackson (collected and submitted by Prof. Wailes). *Clarke County* U. S. G. S. sta. 2630, Garlands Creek, at

bridge, 4½ or 5 miles northeast of Shubuta; U. S. G. S. sta. 6471, Bluff on Garlands Creek, 100 feet above bridge on road to Quitman, about 5 miles northeast of Shubuta. LOUISIANA, *Franklin Parish:* U. S. G. S. sta. 10456, Water well at Winnsboro, depth 552 feet. *Grant Parish:* U. S. G. S. sta. 2003, Creole Bluff, Montgomery. *La Salle Parish:* U. S. G. S. sta. 8931, Urania well no. 1, drilled by the Simms Oil Co. at Urania, depth 1890–1915 feet. ARKANSAS, *Bradley County:* U. S. G. S. sta. 2404, middle of sec. 8, T. 12 S., R. 9 W., 30 yards northwest of Lee Hamaker's house from a bored well 30 feet below surface.

TURRITELLA PERDITA Conrad
Plate 32, figure 11

Turritella perdita CONRAD, *1865*, Am. Jour. Conchology, vol. 1, p. 141, pl. 10, fig. 10.—?CALL, *1891*, Arkansas Geol. Survey, Ann. Rept. for 1889, pt. 2, p. 8.—HARRIS, *1894*, Arkansas Geol. Survey, Rept. for 1892, pp. 89, 92, 170.

Turritella jacksonensis COOKE, *1926*, Washington Acad. Sci., Jour., vol. 16, no. 5, p. 136, fig. 8.

Shell small for the genus, Spire acute, abruptly tapering. Whorls few in number about twice as wide as high, slightly concave, angulated anteriorly and posteriorly and sharply constricted at the linear but very distinct and deeply impressed sutures. Apical whorls smooth, three indistinct revolving lines appearing on about the third whorl, gradually becoming more prominent with the growth of the shell; secondary lirae developed on the fourth and later whorls, variously placed with respect to the primary lirae, but usually the two strongest of the secondaries appearing between the primaries, and occasionally the secondaries assuming a size comparable to that of the primaries, marking the adult whorls with five or six subequal lirae; strength of the sculpture variable through a wide range in a long suite of specimens, the most common variation being the development of the posterior primary lira into an indistinct carina that makes the whorls more obviously concave; base of body whorl marked by numerous (ten or more) indistinct, subequal, fine revolving lines. Incrementals distinct, strongly arcuate, attaining their maximum retraction a little behind the median of the whorl and reflexed slightly just behind the suture; cutting the spiral sculpture rather strongly in some specimens and slightly beading the revolving lirae. Parietal callus indistinct, small. Aperture subquadrate; outer lip very thin and fragile, not preserved complete on any of the specimens at hand.

Dimensions: Not given by Conrad for the holotype. Holotype of *Turritella jacksonensis* Cooke, height, 20.0 mm; greatest diameter, 7.5 mm. Figured specimen, height, 24.0 mm; greatest diameter, 8.5 mm. The figured specimen is slightly broken at the aperture.

Type material: A lectotype and two paratypes in the collection of the Philadelphia Academy of Natural Science no. 13233. Holotype of *Turritella jacksonensis*. U. S. Nat. Mus. no. 353944. Figured specimen, U. S. Nat. Mus. no. 498000.

Type locality: Given by Conrad as Enterprise, Mississippi. Aldrich (see page 276) has pointed out the error in this locality and has corrected it to Garland's Creek, 3 miles east of Shubuta, Clarke County, Mississippi. Figured specimen, U. S. G. S. sta. 3735, Moodys Branch, Jackson, Hinds County, Mississippi. Jackson group, Moodys marl.

Turritella perdita differs from *T. alveata*, with which it is associated at Jackson, particularly in its much greater apical angle. The sculpture on *T. perdita* is much more irregular and indistinct than is that of the other common species of the Moodys marl. *Turritella lowei*, also of the Moodys marl at Jackson, has a more gently tapering spire than *T. perdita* and, although the sutures are deeply cut, the whorls are more rounded and are marked with very feeble revolving lines that do not appear until the adolescent stage. *Turritella rivurbana* of the Moodys marl is a more gently tapering form, and the adult whorls are marked by two strong revolving cords, one near the anterior and one close to the posterior suture, the intervening space being unsculptured.

Cooke described a variant of this species under the name *Turritella jacksonensis*. His type specimen exhibits a strongly developed posterior primary lira that indistinctly carinates the whorl just in front of the suture, and the spirals of the holotype have been lightly beaded by the strong cross cutting of the well-developed growth lines. In a long suite of specimens it is possible to find every

stage between *jacksonensis* Cooke and the typical *perdita* of Conrad, and the two names have been united.

Harris recorded *Turritella perdita* from the Jacksonian sediments of Arkansas, and Call doubtfully referred some of his Arkansas material to this species, but the extensive collections of Arkansas Jackson material in the National Museum yield no specimens conspecific with the typical Mississippi form. *T. alveata* and *T. clevelandia* are both present in the Arkansas beds, and possibly Harris and Call erroneously identified material referable to one of these two species.

Conrad's original figure, which is not very good, and Cooke's excellent illustration of *T. jacksonensis*, are the only figures of this species available in the literature.

Distribution.—Jackson group, Moodys marl. MISSISSIPPI, *Clarke County:* U. S G. S. stas. 330, 2630, Garlands Creek, 4½ miles east of Shubuta; *Hinds County:* U. S. G. S. sta. 54, Green's marl bed, Jackson; U. S. G. S. sta. 59, Bailey's marl bed, Jackson; U. S. G. S. stas. 60, 3735, 4250, 6458, 6462 and 10377, Moodys Branch, Jackson; U. S. G. S. sta. 3734, south of pump house, Jackson. ?LOUISIANA, *Rapides Parish:* U. S. G. S. sta. 7247, Boyce Oil Co., 6 miles southwest of Boyce, from a depth of 1535–2766 feet.

TURRITELLA CLEVELANDIA Harris
Plate 31, figures 9, 12

Turritella clevelandia HARRIS, *1894*, Arkansas Geol. Survey, Rept. for 1892, pt. 2, pp. 92, 95, 97, 170, 174, pl. 6, fig. 9.—VAUGHAN, *1896*, U. S. Geol. Survey Bull. 142, p. 50.—Not HARRIS, *1897*, Bull. Am. Paleontology, vol. 2, no. 9, p. 32 (= *Turritella gilberti* Bowles).
Turritella mortoni Conrad. CALL, *1891*, Arkansas Geol. Survey Ann. Rept. for 1889, pt. 2, p. 8.

Shell small for the genus. Spire high, acute, very slender, gradually tapering. Whorls numerous, about as wide as high in the young stages, becoming relatively wider in adolescence. Sutures linear, distinct, very deeply impressed, sharply constricting the whorls. Apical whorls marked by three subequal revolving cords, symmetrically arranged; anterior primary lira gradually becoming stronger relatively with the growth of the shell until on the adult whorls it forms an obscure carina; secondary lirae appearing on the fifth whorl between the primary cords and between the posterior lira and the suture, becoming slightly stronger in the adult stages but not approximating the primary cords in size; numerous fine revolving lines appearing in adolescence and microscopically sculpturing the entire surface of the adolescent and adult whorls; base of body sculptured only by extremely fine threading. Incrementals strongly marked, deeply arcuate, the axis of the sinus situated a little behind the median of the whorl, very sharply recurved just behind the suture. Parietal wash small, inconspicuous. Aperture subcircular.

Dimensions: Lectotype, height, 24.0 mm; greatest diameter, 5.5 mm.

Type material: A number of syntypes, U. S. Nat. Mus. no. 135142 from which a lectotype, U. S. Nat. Mus. no. 498010 has been selected.

Type locality: White Bluff, Jefferson County, Arkansas. Jackson Group.

Turritella clevelandia is one of the most abundant and most widespread of the Jackson Turritellas. The small size, very slender form and dominantly tripartite sculpture distinguish this species from its associates. The nearest analogous species seems to be *Turritella gilberti* of the upper Wilcox of Alabama, but the lower Eocene form may be readily distinguished by its less deeply incised sutures and more-inflated whorls. The material from Woods Bluff was first identified by Harris as *T. clevelandia*, but in 1899 he pointed out the differences between the two forms, not, however, naming the older species.

Turitella clevelandia is represented only in the central part of the Gulf province, from Louisiana through Arkansas and into East Texas. It has not been recorded from Mississippi or Alabama.

Distribution.—Jackson group. LOUISIANA, *Grant Parish:* U. S. G. S. sta. 2638, bluff at Montgomery, ¼ to ½ mile below ferry landing. *Sabine Parish:* U. S. G. S. sta 8104, well at Negreet, 9 miles southwest of Many, T. 6 N., R. 12 W. ARKANSAS, *Cleveland County:* U. S. G. S. sta. 2231, well at Rison, NE. ¼ sec. 1, T. 9, S. R. 11 W.; U. S. G. S. sta. 2410, well, 90 feet below surface at the Orton place, Toledo; U. S. G. S. sta. 2413, well at Rison, SE. ¼ SW.

¼ sec. 1, T. 9 S., R. 11 W., from a depth of 30 to 50 feet; U. S. G. S. sta. 2403, Saline River, left bank, ¾ mile above Vince Bluff; *Bradley County:* U. S. G. S. sta. 2404, middle of sec. 8, T. 12 S., R. 9 W., 30 yards northwest of Lee Hamaker's house, from a bored well 30 feet below the surface. *St. Francis County:* U. S. G. S. sta. 4156, Big Crow Creek, Crowleys Ridge; U. S. G. S. sta. 4157, Crowleys Ridge. *Jefferson County:* U. S. G. S. sta. 2220, White Bluff, W. ½, SE ¼ sec. 19, T. 2 S., R. 10 W. and W. ½ NE¼ sec. 30, T. 3 S., R. 10 W. TEXAS, *Sabine County:* U. S. G. S. sta. 4787, ¾ mile below Robinson's Ferry, Sabine River; U. S. G. S. sta. 10742, Robinson's Ferry, 2 miles north of Fairdale, Sabine River.

V. MULTICOSTATE GROUP

TURRITELLA SAFFORDI Gabb

Plate 33, figures 1, 8

Turritella saffordi GABB, *1860*, Acad. Nat. Sci. Philadelphia, Jour., 2d ser., vol. 4, p. 392, pl. 68, fig. 12.—HARRIS, *1896*, Bull. Am. Paleontology, vol. 1, no. 4, pp. 109, 110, pl. 11, fig. 7.—LOWE, *1933*, Mississippi Geol. Survey, Bull. 25, p. 9.—GARDNER, *1935*, Univ. Texas, Bull. 3301, p. 283. Not HARRIS, *1896*, Bull. Am. Paleontology, vol. 1, no. 4, pl. 11, fig. 8 (=*Turritella mortoni* var. *mediavia* Bowles, n. subsp.). Not PLUMMER, *1933*, Univ. Texas, Bull. 3232, pp. 547, 815, pl. 10, fig. 1.

Not *Turritella saffordii* GABB, *1864*, California Geol. Survey, Paleontology, vol. 1, p. 135, pl. 21, fig. 93.—GABB, *1866*, Am. Jour. Conchology, vol. 2, p. 89.—GABB, *1869*, California Geol. Survey, Paleontology, vol. 2, p. 228.—WHITE, *1885*, U. S. Geol. Survey, Bull. 15, p. 28. (=*Turritella pachecoensis* Stanton, 1896.) WATTS, *1894*, California Mining Bureau, Bull. 3, p. 62 (=*?Turritella andersoni* Dickerson).

Turritella mortoni Conrad. LOWE, *1933*, *ex parte*, Mississippi Geol. Survey, Bull. 25, p. 10 (stations 5586 and 5592 only).

Spire high, gradually tapering. Whorls numerous, rounded, slightly carinate basally, but not overhanging the sutures. Sutures linear but sharply defined and deeply impressed; posterior portion of the whorl constricted sharply just in front of the suture. Extreme apical whorls unknown, but early apical whorls exhibiting very fine revolving lines over entire surface, particularly apparent on the extreme anterior, rounded portion of the whorl, just under the obscure carina. Revolving ribs almost obsolete on the older whorls, except for the strongest sculpture under the carina, which consists of three distinct revolving cords. Growth lines conspicuous, deeply flexed well above the middle of the whorl, reflexed anteriorly and meeting the anterior suture just a little behind their intersection with the posterior suture. Complete aperture unknown.

Dimensions: "Length (restored) 2.2 in., width of body whorl .6 in., length of mouth .4 in." (Gabb, 1860). Figured specimens (U. S. Nat. Mus. no. 495151), height, 74.0 mm; greatest diameter, 25.0 mm (specimen broken apically; would probably have measured at least 100 mm when complete). (U. S. Nat. Mus. no. 495152), height, 17.0 mm; greatest diameter, 4.0 mm (an incomplete juvenile specimen).

Type material: Apparently lost. The type cannot be found in the collections of the Philadelphia Academy of Natural Sciences nor in the Safford collection of Vanderbilt University. Figured specimens, U. S. Nat. Mus. nos. 495151 and 495152.

Type locality: "Hardeman Co., Tenn. Prof. Safford. From the light-gray limestone alternating with marls of the Ripley Group" (Gabb, 1860). Figured specimens: (U. S. Nat. Mus. No. 495151) U. S. G. S. sta. 5586, ravine just north of the Booneville road, 3 miles northwest of Ripley, Tippah County, Mississippi; (U. S. Nat. Mus. no. 494152), U. S. G. S. sta. 6091, milepost 481, east of Middleton, Hardeman County, Tennessee. Midway group, Clayton formation.

When well preserved this species cannot be readily confused with any other in the Gulf province. The characteristically smooth whorls, with their slight carination, and the presence of three well-defined cords on the rounded anterior side are sufficiently distinctive to set this species apart.

Harris (1894, pl. 3, fig. 5) figured a specimen from U. S. G. S. sta. 2437, 1¾ miles north of Bradford, White County, Arkansas, which he referred to *Turritella mortoni* var. Similar specimens were recorded by him from U. S. G. S. sta. 2223, two-thirds of a mile north of Bradford, and U. S. G. S. sta. 2438, 2 miles north of Bradford. In 1896 he (Harris 1896, pl. 11, fig. 8) reproduced this figure and referred the material to *T. saffordi*. The material in the collections of the U. S. National Museum

from these Geological Survey stations is too poorly preserved to be specifically identifiable, but the specimens seem to have closer affinities with *Turritella mortoni mediavia*, n. subsp., than with any other species.

The larger of the figured specimens (pl. 33, fig. 1) is the one referred to *T. mortoni* by Lowe in 1933. This specimen and others from the same locality seem somewhat different from typical *T. saffordi* from Hardeman County, Tennessee, but these differences may be due primarily to their much larger size and to differences in the state of preservation. Until better material proves specific variation they are included with the Tennessee material.

Plummer has figured a specimen from the quarry south of Ola, Kaufman County, Texas, in the Kincaid formation, and referred it to *Turritella saffordi*, but the figure seems to represent a form quite distinct from that described by Gabb from Tennessee. Miss Gardner did not record *T. saffordi* in her monograph on the Texas Midway.

The name *saffordi* or *saffordii* has been used widely in the literature on California paleontology, due to the erroneous identification of a California Paleocene species by Gabb in 1864. This species, specifically distinctly from the Tennessee Eocene material was subsequently named *Turritella pachecoensis* by Stanton.

Distribution.—Midway group, Clayton formation. MISSISSIPPI, *Tippah County:* U. S. G. S. sta. 5586, ravine just north of the Booneville road, 3 miles northeast of Ripley (large form); U. S. G. S. sta. 5592, bluff on Owl Creek, 3 miles northeast of Ripley on land of William Hill, at spring adjacent to house (large form). TENNESSEE, *Hardeman County:* U. S. G. S. stas. 6091 and 6495 milepost 481, 1½ miles east of Middleton.

TURRITELLA POTOMACENSIS
Clark and Martin

Turritella potomacensis CLARK and MARTIN, *1901*, Maryland Geol. Survey, Eocene, pp. 67, 70, 71, 76, 77, 149, pl. 27, figs. 2, 3.—CLARK and MILLER, *1912*, Virginia Geol. Survey, Bull. 4, pp. 104, 106, 107, 119, 120.

Shell small. Spire high, slender, very gently tapering. Whorls numerous, wider than high, straight-sided in the young stages, concave and carinated basally when adolescent and adult. Sutures linear, indistinct between the apical, more deeply incised between the adult whorls. Apical whorls marked by two strong, subequal revolving lirae on the anterior half of the whorl, with three smaller cords on the posterior half; numerous fine threads added on the adolescent and adult whorls, irregularly spaced with respect to the primary cords; anterior primary lira becoming relatively more prominent with the growth of the shell until on the eighth or ninth whorl it forms a distinct carination, which becomes very pronounced on the adult whorls; under side of carina marked by two or three fine, indistinct, revolving lines. Incrementals distinct but not strongly marked, deeply flexed with the maximum of the curvature attained slightly behind the median of the whorl, slightly reflexed below the carina. Aperture not preserved entire on either of the type specimens.

Dimensions: "Length, 45 mm; width, 10 mm." (Clark and Martin, 1901.)

Type material: Two cotypes in the collection of the Maryland Geological Survey, the Johns Hopkins University, Baltimore, Maryland.

Type locality: Pope's Creek, Charles County, Maryland. Wilcox group, Nanjemoy formation.

Turritella potomacensis is recorded only from the Nanjemoy formation of Maryland and Virginia and is very scantily represented in these deposits. There are no specimens of *Turritella* from either Popes Creek or Woodstock in the collections of the National Museum. The species is quite distinct from *T. mortoni* of the underlying Aquia, being much smaller, less prominently carinate, and with five instead of three revolving lirae on the apical whorls. Its closest analogue is *Turritella gilberti*, n. sp., of the upper Wilcox of Alabama and Mississippi, but this southern species has more quadrangular whorls, separated by wider and more deeply impressed sutures, and is less prominently carinate. *T. gilberti* is also characterized by three revolving lirae and belongs to the tricostate rather than the multicostate group.

Distribution.—Wilcox group, Nanjemoy formation. MARYLAND, *Charles County:*

(Maryland Geological Survey and the private collection of S. F. Blake) Popes Creek. VIRGINIA, *Stafford County:* (Maryland Geological Survey) Woodstock.

TURRITELLA OBRUTA Conrad
Plate 33, figure 2

Turritella obruta CONRAD, *1833*, Fossil shells, p. 45.—CONRAD, *1835*, Fossil shells (republication), p. 40, pl. pl. 15, fig. 12.—PALMER, *1937*, Bull. Am. Paleontology, vol. 7, no. 32, p. 203, pl. 26, figs. 12–14; pl. 82, fig. 11. Not CLARK and MARTIN, *1901*, Maryland Geol. Survey, Eocene, p. 149, pl. 27, fig. 4.
Turritella lineata LEA, *1833*, Contributions to geology, 130, pl. 4, fig. 121.
?*Turritella* mut. *tiga* DEGREGORIO, *1890*, Faune éocénique de l'Alabama, p. 126, pl. 11, fig. 22. —PALMER, *1937*, Bull. Am. Paleontology, vol. 7, no. 32, p. 190.

Spire high, rather abruptly tapering. Whorls rounded, constricted at the linear but distinct and deeply impressed sutures. Apical whorls marked by five subequal distinct but not prominent revolving lirae, symmetrically placed on the whorl; fine secondary threading arising on the third and later whorls, variously placed with respect to the five primary lirae; the two most posterior secondary lirae gradually increasing in size with the growth of the shell until on the adult whorls they are equal to the primaries in strength; the other secondaries remaining small and indistinct. Incrementals deeply flexed, the maximum of the curvature attained between the median and the posterior third of the whorl, sharply flexed again just behind the suture. Aperture rounded.

Dimensions: Not given by Conrad for the holotype. Figured specimen, height, 31.0 mm; greatest diameter, 9.5 mm.

Type material: A lectotype and six paratypes in the collection of the Philadelphia Academy of Sciences. A holotype (no. 5668) and a paratype (no. 5669) of *Turritella lineata* Lea, also in the Philadelphia Academy. DeGregorio's types at his former home in Palermo, Sicily. Figured specimen, U. S. Nat. Mus. no. 497996.

Type locality: Claiborne Bluff, Alabama River, Monroe County, Alabama. The figured specimen is a topotype. Jackson group, Moodys marl.

Turritella obruta has the inflated whorls and abruptly tapering spire of a *Mesalia*, but the deeply reflexed growth lines indicate a sinuosity of the outer lip much more comparable to that of *Turritella*. This species most closely resembles *T. pleboides* of the Louisiana Claiborne, but this western form has more deeply incised sutures, and is a much more slender and less inflated species.

Turritella obruta is confined to the Moodys marl and is not recorded outside of Alabama.

Distribution.—Jackson group, Moodys marl. ALABAMA, *Monroe County:* U. S. G. S. stas. 263, 2391 and 2867, Claiborne Bluff, Alabama River.

TURRITELLA PLEBOIDES Vaughan
Plate 33, figure 7

Turritella pleboides VAUGHAN, *1895*, Am. Geologist, vol. 15, p. 213.
Mesalia pleboides VAUGHAN, *1896*, U. S. Geol. Survey, Bull. 142, pp. 36, 44, pl. 3, figs. 4, 5, 6.—PALMER, *1937*, Bull. Am. Paleontology, vol. 7, no. 32, p. 208, pl. 27, figs. 5, 11, 12.

Shell small. Spire rather abruptly tapering. Whorls nine in number in the lectotype, rounded, the maximum inflation submedial, sharply constricted at the linear but deeply impressed sutures. Extreme apex not preserved; the earliest whorls known exhibiting two prominent subequal revolving lirae, about as close to each other as they are to the sutures; a less prominent secondary lira close to the anterior suture and another near the posterior; additional small lirae arising on the later whorls between the two primaries and between the sutures and the primaries, increasing in size while the two prominent lirae of the apical whorls are decreasing until on the body whorl of the lectotype they are barely distinguishable from the primaries; body whorl marked by 14 subequal distinct but not prominent revolving lirae in addition to the two primaries, which are but little larger than the secondaries. Incrementals distinct, strongly marked on the adult whorls, deeply arcuate, the maximum of the curvature attained between the posterior third and the median of the whorl, slightly recurved just behind the suture. Parietal wash thin, inconspicuous. Aperture rounded; outer lip thin, fragile, not preserved complete on the type material.

Dimensions: Lectotype, height, 22.0 mm; greatest diameter, 7.0 mm.

Type material: Numerous syntypes, U. S. Nat. Mus. no. 147040 of which one, renumbered no. 495175, has been selected as the lectotype.

Type locality: U. S. G. S. sta. 2911, Mt. Lebanon, Bienville Parish, Louisiana. Claiborne group, St. Maurice formation.

Like *Turritella obruta* of the Moodys marl, *T. pleboides* bears a strong superficial resemblance to *Mesalia*, but the strongly reflexed growth lines indicate a close *Turritella* affinity. The whorls are inflated and very sharply constricted at the deep sutures, giving a strong suggestion of loose coiling, distinguishing the species from *T. obruta*. Vaughan pointed out the resemblance between this Claiborne species and *T. plebeia* Say of the Maryland Miocene.

Turritella pleboides has not been recorded outside of Louisiana.

Distribution.—Claiborne group, St. Maurice formation. LOUISIANA, *Bienville Parish:* U. S. G. S. sta. 2033, "Holston's well," 5 miles southeast of Gibbsland; U. S. G. S. sta. 2034, Mr. Holston's sec. 17, T. 18 R. 5 W; U. S. G. S. sta. 2035, Bluff on Hammett's Branch, sec. 30, T. 18, R. 5 W; U. S. G. S. sta. 2045, well no. 1, on sec. 17, T. 18 R. 6 W.; U. S. G. S. sta. 2400, Hammett's Branch, 2 miles east of Mt. Lebanon; U. S. G. S. sta. 2911, Mt. Lebanon; U. S. G. S. sta. 2917, Hammett's Branch, SW ¼ sec. 30, T. 18 N. R. 6 W. *Claiborne Parish:* U. S. G. S. sta. 10794, secs. 1, 2, 11, 12, T. 19 N. R. 6 W. Elevation 300–350 feet.

TURRITELLA HUMEROSA SUBGROUP

TURRITELLA HUMEROSA Conrad

Plate 33, figure 10

Turritella humerosa CONRAD, *1835*, Geol. Soc. Pennsylvania, Trans. vol. 1, pt. 2, p. 340, pl. 13, fig. 3.—CLARK, *1896*, U. S. Geol. Survey, Bull. 141, pp. 40, 42, 44, 57, 70, pl. 14, fig. 1.—CLARK and MARTIN, *1901*, Maryland Geol. Survey, Eocene, pp. 148, 149, pl. 27, figs. 1, 1*a*.—CLARK and MILLER, *1912*, Virginia Geol. Survey, Bull. 4, pp. 92, 94, 95, 119, 120.—GUILLAUME, *1924*, Soc. géol. France, Bull., sér. 4, vol. 24, p. 290.—TROWBRIDGE, *1932*, *ex parte*, U. S. Geol. Survey, Bull., 837, pl. 38, fig. 7 (Not pl. 31, figs. 6, 7, Nor pl. 38, fig. 8).—GARDNER, *1935*, Univ. Texas, Bull., 3301, pp. 288–290 (used in the group sense). Not HARRIS, *1896*, Bull. Am. Paleontology, vol. 1, no. 4, pp. 15, 16, 32, 36, 110, 111, pl. 11, figs. 10–13 (used in the group rather than the specific sense for the related Midway forms).—Not HARRIS, *1899*, Bull. Am. Paleontology, vol. 3, no. 11, pp. 75, 76, pl. 10, figs. 5–7 (used in the group sense for the Alabama Wilcox forms).—Not HARRIS, *1900*, Louisiana Geol. Survey, Rept. for 1899 (Special Rept. 6), p. 308, pl. 55, fig. 5 (= *Turritella bellifera* Aldrich).—Not VEATCH and STEPHENSON, *1911*, Georgia Geol. Survey, Bull. 26, pp. 217, 219, 223, 224 (= *Turritella aldrichi* Bowles, n. sp.).—Not STEPHENSON and VEATCH, *1915*, U. S. Geol. Survey, Water-Supply Paper 341, pp. 68, 69 (= *Turritella aldrichi* Bowles, n. sp.)

Not *Turritella humerosa* Conrad, var. COOKE, *1926*, Alabama Geol. Survey Special Rept. 14, pl. 94, fig. 1 (= *Turritella multilira* Whitfield).

Turritella (*Haustator*) *humerosa* COSSMANN, *1912*, Essais de paléoconchologie comparée, vol. 9, p. 118.

Shell very large for the genus. Spire high, slender, acute, very gradually tapering. Sutures linear, distinct, but not deeply impressed. Whorls straight-sided in the young stages, in the adult slightly carinated posteriorly by a subsutural collar, which arises on the adolescent whorls. Extreme apex not preserved on any of the specimens studied; earliest whorls observed bearing three to five small subequal revolving lirae; additional lirae introduced early, becoming very numerous on the later whorls, increasing in size with the growth of the shell while the primary lirae are decreasing until on the fifteenth to twentieth whorls there are 30 or more fine, subequal lines marking the whorl; linear sculpture continuing over the subsutural collar, which is not formed by a strengthening of an apical cord, as is the carina of *Turritella mortoni*, but by a thickening of the shell anterior to the suture, accentuated by a slight overriding of each whorl upon the preceding whorl. Incrementals strongly flexed at the posterior third of the whorl and reflexed just behind the suture in a manner similar to those of *Turritella mortoni*. Parietal callus well developed. No complete aperture observed.

Dimensions: Not given by Conrad for the holotype. Figured specimen, height, 106.0 mm; greatest diameter, 22.5 mm.

Type material: A lectotype and four paratypes in the collection of the Philadelphia Academy of Natural Sciences. Figured specimen, U. S. Nat. Mus. no. 497994.

Type locality: Piscataway, Prince Georges County, Maryland. The figured specimen

is a topotype. Wilcox group, Aquia formation.

As in the case of *Turritella mortoni*, *T. humerosa* is cited widely in the literature, but seldom in a specific sense, the name being utilized frequently to characterize that group of Wilcox and Midway Turritellas distinguished by a subsutural collar or carination and straight-sided, multicostate whorls. As restricted in this paper, *Turritella humerosa* includes only those forms from the Aquia formation of Maryland and Virginia. In the Wilcox of the southern states the group of *T. humerosa* is represented by three species, *Turritella multilira* Whitfield, *T. bellifera* Aldrich and *T. praecincta* Conrad. *T. humerosa sanjuanensis* Bowles, n. subsp., from the lower Eocene of northern Mexico is much more closely allied to the typical form from the Aquia formation of Maryland and Virginia than it is to the southern Wilcox and Midway analogues. *T. humerosa biboraensis* Gardner, *T. claytonensis* Bowles, n. sp., and *T. aldrichi* Bowles, n. sp., represent the group in deposits of Midway age. The only related species known from deposits younger than lower Wilcox is *T. mcbeanensis* Bowles, n. sp., from the McBean (Claiborne) formation of South Carolina and Georgia. This species marks the expiration of the group in the East American Eocene.

Turritella humerosa differs from *T. bellifera* of the Alabama Wilcox in its finer and more numerous spiral markings and its more rounded and less prominent subsutural collar. *Turritella humerosa biboraensis*, the only other form with which the Maryland species might be confused, is a more slender species with finer lirations.

Turritella humerosa is restricted to the Aquia formation, and, like *Turritella mortoni*, is most common in the lower, or Paspotansa substage.

Distribution.—Wilcox group, Aquia formation. MARYLAND, *Anne Arundel County:* U. S. G. S. sta. 3934, South River, 2½ miles from Annapolis. *Prince George County:* U. S. G. S. sta. 13451 and U. S. Nat. Mus. no. 6002, Piscataway; U. S. Nat. Mus. no. 6461, 6 miles east of Washington; U. S. G. S. sta. 2029, ravine, 1 mile east of Fort Washington; U. S. G. S. sta. 2370, three-fourths of a mile back of Fort Washington. VIRGINIA, *Stafford County:* U. S. Nat. Mus. nos. 2504 and 2505, Aquia Creek; U. S. G. S. sta. 12934, Stafford Courthouse; U. S. G. S. stas. 2030, 13809 and 13810, bluffs on the Potomac River at the mouth of Aquia Creek; U. S. G. S. sta. 2347, west bank of Potomac River, two-thirds of a mile north of the mouth of Potomac Creek.

TURRITELLA HUMEROSA BIBORAENSIS Gardner

Turritella biboraensis Gardner, *1935*, Univ. Texas, Bull. 3301, pp. 290–291, pl. 25, fig. 3.
Turritella sp. cf *T. humerosa* Conrad. GARDNER, *1935*, Univ. Texas, Bull. 3301, p. 289, pl. 25, fig. 2.

Spire high? (only five whorls preserved on the incomplete holotype), very gradually tapering. Whorls straight-sided, higher than wide, marked by a distinct subsutural collar, on the upper surface of which the linear, indistinct sutures are impressed. Sculpture consisting of numerous very fine, subequal, revolving lines, increasing in size with the growth of the shell, but never becoming very prominent. Incrementals reflexed as in the other members of the *Turritella humerosa* group. Aperture not preserved.

Dimensions: Holotype, height, 42.4 mm; greatest diameter, 15.9 mm.

Type material: Holotype, U. S. Nat. Mus. no. 370989.

Type locality: U. S. G. S. sta. 6583, Bibora tank on the Indio Ranch, 18 miles southeast of Eagle Pass, Maverick County, Texas. Midway Group, Kincaid formation.

Turritella humerosa biboraensis is most closely related to the typical *T. humerosa* of the lower Eocene of Maryland and Virginia, differing from the northern form, however, in its smaller size and finer revolving sculpture. The well-preserved, but incomplete specimen figured by Miss Gardner with the designation "*Turritella* sp. cf. *T. humerosa* Conrad," from Limestone County, is tentatively placed with the border form. It seems to exhibit the same sculpture pattern, although the collar is more distinct and is separated from the suture by a narrow, finely sculptured band.

Distribution.—Midway group, Kincaid formation. TEXAS, *Limestone County:*?U. S. G. S. sta. 11936, 2½ miles northwest of Groesbeck. *Maverick County:* U. S. G. S.

sta. 6583, Bibora tank on the Indio Ranch, 18 miles southeast of Eagle Pass; U. S. G. S. sta. 11758, Indio wells on the Indio Ranch, 29 miles southeast of Eagle Pass; U. S. G. S. sta. 11763, 3½–4 miles southwest of the Windmill (Jacal) Ranch house, on Las Islas crossing road.

TURRITELLA HUMEROSA SANJUANENSIS BOWLES, n. subsp.
Plate 34, figure 18

Spire elongated, very gradually tapering. Whorls narrow, much higher than wide, with almost straight sides, contracted slightly posterior to the suture and again just anterior to the subsutural collar. Sutures linear and distinctly impressed, particularly after the appearance of the subsutural collar, which slightly overrides them on the adult whorls. Apical whorls not preserved on any of the specimens; earliest adolescent whorls marked by six or seven distinct but not prominent subequal revolving lines; secondary lines added with the growth of the shell until on the adult whorls there are ten or twelve lirae, the secondaries increasing in prominence until they are as strong as the primaries; posterior margin of adult whorls thickened into a distinct subsutural collar, comparable to that of *Turritella humerosa;* a slightly contracted space immediately behind the anterior suture sculptured only by very fine revolving lines. Incrementals distinct, strongly marked on the adult whorls, sharply recurved at about the posterior third of the whorl, slightly reflexed just behind the suture, cutting the revolving lirae on the adult whorls into a series of irregular beads. Aperture unknown.

Dimensions: Holotype (an incomplete individual with but three adult whorls preserved), height, 30.0 mm; greatest diameter, 10.5 mm. Paratype (an incomplete individual with 3½ adolescent whorls preserved), height, 13.5 mm; greatest diameter, 4.0 mm.

Type material: A holotype, U. S. Nat. Mus. no. 494986, and a paratype, U. S. Nat. Mus. no. 494987.

Type locality: U. S. G. S. sta. 13487, upstream section, just east of the fault, Rio San Juan, Nuevo León, Mexico. Lower Wilcox group, undifferentiated.

The distinct subsutural collar of *Turritella humerosa sanjuanensis* indicates its close relationship to the *T. humerosa* group of the Eastern Gulf province, but it is readily distinguished from the typical form of the Maryland Aquia formation by the extreme elongation of the whorls and the very gradually tapering spire. The subsutural collar is more closely comparable to that of *T. humerosa*, s.s., than to the posterior carina of *T. bellifera*, for it is formed by a thickening of the shell over which the sculpture continues unchanged, rather than the extreme development of one of the revolving lirae.

The only other species of the Turritellidae with which *Turritella humerosa sanjuanensis* is associated is *Mesalia sayi* Bowles, n. sp., so that a close dating of the deposits from which *T. sanjuanensis* has been recorded is rendered impossible from the Turritellas alone.

Distribution.—Lower part of the Wilcox group. MEXICO, *Nuevo León:* U. S. G. S. sta. 13487, upstream section, Rio San Juan, just east of fault; U. S. G. S. sta. 13550, upstream section, Rio San Juan, just west of fault; U. S. G. S. stas. 13490 and 13491, 3 miles west of Altamira Ranch, Coyote Concession; U. S. G. S. sta. 13492, 3 miles northeast of La Almeda Ranch, Coyote Concession; U. S. G. S. sta. 13450, on road from Rancho Durazno to Rancho Las Flores, 520 meters southeast of the crossing of the East-West brecha.

TURRITELLA CLAYTONENSIS
Bowles, n. sp.
Plate 34, figures 14, 15

Turritella humerosa Conrad. HARRIS, *1896, ex parte,* Bull. Am. Paleontology, Vol. 1, no. 4, p. 110, pl. 11, fig. 12 (Not CONRAD, *1835*).

Spire high, more abruptly tapering than is customary in the *Turritella humerosa* group. Whorls flattened laterally and marked by a distinct subsutural collar, which encroaches slightly onto the preceding whorl, the suture being shallowly impressed on the upper surface of the collar. Both apical and adult whorls sculptured only by numerous very fine, distinct, subequal, evenly spaced revolving lines. Growth lines sharply and deeply curved at about the median of the whorl, and then reflexed, meeting the anterior suture just a

little behind their intersection with the posterior suture. Aperture not preserved complete on any of the specimens observed.

Dimensions: Holotype, height, 68.0 mm; greatest diameter, 26.0 mm. The specimen is broken both at the aperture and the apex.

Type material: A holotype, U. S. Nat. Mus. no. 131637.

Type locality: U. S. G. S. sta. 264, Prairie Creek, Wilcox County, Alabama. Midway group, Clayton formation.

The very distinctive, fine, evenly spaced sculpture, the abrupt tapering of the spire, the large size, and the encroachment of each whorl over the preceding whorl differentiate *Turritella claytonensis* from typical *T. humerosa* and its southern Wilcox analogues. *Turritella aldrichi* of the Alabama Midway is also a smaller, more gradually tapering species.

The specimen figured by Harris in 1896 is the one selected for the holotype of *T. claytonensis*. Harris referred this form to *T. humerosa*.

Turritella claytonensis has not been recorded outside the state of Alabama, and it is restricted to the lower Midway Clayton horizon.

Distribution.—Midway group, Clayton formation. ALABAMA, *Wilcox County:* U. S. G. S. sta. 264, Prairie Creek. *Barbour County:* U. S. G. S. sta. 12164, cut on Central of Georgia Railroad, near Clayton.

TURRITELLA ALDRICHI Bowles, n. sp.
Plate 34, figures 11, 17

Turritella humerosa? Conrad. ALDRICH, *1886*, Alabama Geol. Survey, Bull. 1, p. 59.

Turritella humerosa Conrad. HARRIS, *1896*, Bull. Am. Paleontology, vol. 1, no. 4, p. 111, pl. 11, fig. 11.—VEATCH and STEPHENSON, *1911*, Georgia Geol. Survey, Bull. 26, pp. 217, 219, 223.—STEPHENSON and VEATCH, *1915*, U. S. Geol. Survey, Water-Supply Paper 341, pp. 68, 69.—BRANTLY, *1920*, Alabama Geol. Survey, Bull. 22, pp. 145, 146. Not CONRAD, *1835*.

Turritella humerosa Conrad, var. ALDRICH, *1894*, Alabama Geol. Survey, Rept. for 1894, pp. 239, 246, pl. 13, fig. 5.

Turritella multilira Whitfield. ALDRICH, *1886*, Alabama Geol. Survey, Bull. 1, p. 59.

Turritella humerosa var. *multilira* Whitfield. ALDRICH, *1894*, Alabama Geol. Survey, Rept. for 1894, pp. 239, 246, pl. 13, fig. 3.—HARRIS, *1896*, Bull. Am. Paleontology, vol. 1, no. 4, p. 111, pl. 11, fig. 10.

Spire high, acute, gently tapering. Whorls straight-sided, marked by a slight thickening just below the sutures, which are narrow but distinctly and deeply impressed. Sculpture of apical whorls consisting of three strong, evenly-spaced revolving lirae, the strongest anterior, the distance between the anterior lira and the suture approximately equal to that between the two lirae, the posterior cord, however, being relatively much closer to the posterior suture. Subsutural collar not pronounced on the extreme apical whorls, gradually becoming stronger with the growth of the shell; strength of the collar variable, in extreme and members being practically absent. Adult sculpture variable in character, usually consisting of numerous very fine, subequal revolving cords, but occasionally with four or five of the cords relatively more prominent, the three apical cords stronger than those of later origin. Incrementals reflexed as in other members of the *Turritella humerosa* group, but more strongly marked than in typical *T. humerosa;* commonly cutting the subsutural collar so as to give it a crenulated or beaded appearance and also slightly beading the spiral lirae at their intersections with the incrementals. No perfect aperture observed.

Dimensions: Holotype, height, 39.0 mm; greatest diameter, 9.0 mm. Paratype, height, 41.0 mm; greatest diameter, 10.0 mm. (Both the holotype and the paratype are broken at the aperture and apex.)

Type material: A holotype, U. S. Nat. Mus. no. 495148 and a paratype, U. S. Nat. Mus. no. 495149.

Type locality: U. S. G. S. sta. 5596, Matthews Landing, Alabama River, Wilcox County, Alabama. Midway group, Naheola formation.

This species is restricted to the Midway group and has been found only in Alabama and Georgia. *Turritella aldrichi* differs from the lower Midway form, *T. claytonensis*, in its coarser sculpture, the persistence of the three distinct ribs on the apical whorls, and in the less pronounced subsutural collar. From *T. biboraensis* of the lower Midway of Texas, it differs in its less distinct subsutural collar, its relatively smaller size, and the coarseness of the revolving striae on the adult whorls. Unfortunately the apical sculpture of the Texas form is unknown.

It is difficult to distinguish some of the

specimens of *Turritella aldrichi* from some specimens of the contemporaneous *T. alabamiensis* Whitfield. The two species represent different groups, *T. alabamiensis* being a fore-runner of the prominent *T. mortoni* group of the Wilcox, while *T. aldrichi* apparently is closely related to the Wilcox *T. humerosa*. When the subsutural collar of *T. aldrichi*, however, is not particularly prominent, the specimens closely resemble individuals of *T. alabamiensis* in which the basal carina is indistinct. The two forms have been separated taxonomically because of their apparent relationships to the later well-established and distinct groups of *T. mortoni* and *T. humerosa*.

Aldrich, in 1894, figured two specimens of this species from Wilcox County, Alabama, in the lower Midway, under the names "*T. humerosa* var." and "*T. humerosa* var. *mutilira* Whitfield." In 1896 Harris reproduced both figures and placed them tentatively under his *T. humerosa*.

Molds obtained from the leached limestones near Preston, Webster County, Georgia, are identifiable as *T. aldrichi*. Veatch and Stephenson (1911, p. 224) recorded *Turritella alabamiensis* from Walls' Crossing, 4½ miles northwest of Ellaville, Schley County, Georgia. This material has not been found in the collections of the National Museum, although the identification was attributed to Vaughan. *T. aldrichi* has been recorded from 5 miles west of Ellaville, but there is no record of *T. alabamiensis* from this locality.

Turritella aldrichi is the only representative of the *T. humerosa* stock found in the upper Midway of the Eastern Gulf province. Miss Gardner (1935, pp. 288–290) recorded molds and badly weathered fragments of a specifically indeterminate *Turritella* allied to the *T. humerosa* group, from the Wills Point formation of Texas. While these fragments are certainly not determinable, they at least establish the presence of the *humerosa* group in the upper Midway of Texas.

Distribution.—Undifferentiated Midway group. GEORGIA, *Webster County:* U. S. G. S. sta. 5483, limestone at Lime Spring, Cole property, 2 miles southeast of Preston. *Schley County:* U. S. G. S. sta. 12092, 5 miles west of Ellaville.

Midway group, Clayton formation. ALABAMA, *Wilcox County:* U. S. G. S. sta. 264, Prairie Creek; U. S. G. S. stas. 281 and 284, Prairie Creek and Allenton, Pine Barren section; U. S. G. S. sta. 283, Black Creek branch of Prairie Creek; U. S. G. S. sta. 3107 in the Camden road, 1 mile west of Oak Hill Postoffice.

Midway group, Naheola formation. ALABAMA, *Wilcox County:* U. S. G. S. stas. 3116, 2671 and 5596, Matthews Landing on the Alabama River.

TURRITELLA MULTILIRA Whitfield

Plate 32, figure 15; plate 34, figure 19

Turritella multilira WHITFIELD, *1865*; Am. Jour. Conchology, vol. 1, p. 266.—HARRIS, *1899*, Bull. Am. Paleontology, vol. 3, no. 11, p. 75, pl. 10, fig. 6. Not ALDRICH, *1894*, Alabama Geol. Survey, Rept. for 1894, pp. 237, 239, 246, pl. 13, fig. 3 (= *Turritella bellifera* Aldrich).

Turritella bellifera Aldrich. ALDRICH, *1886*, Alabama Geol. Survey, Bull. 1, p. 58.

Turritella multilirata WHITFIELD, *1899*, New York Acad. Sci., Annals, vol. 12, no. 8, p. 177. Not ADAMS and REEVE, *1850*.

Turritella humerosa Conrad, var. COOKE, *1926*, Alabama Geol. Survey, Special Rept. 14, pl. 94, fig. 1.

Spire high, narrow, gradually tapering. Whorls numerous, wider than high, straight-sided, slightly carinated posteriorly, separated by linear, indistinct sutures. Apical whorls not retained on any of the specimens observed; earliest whorls known marked by seven or eight fine revolving lirae; more fine revolving lines, variously placed with respect to the earliest sculpture, continuously added with the growth of the shell, until there are twenty or more on the body whorl; posterior lira becoming relatively stronger and on the later adolescent whorls forming a distinct but not very prominent subsutural carina, but becoming sharper and more prominent on the adult whorls. Incrementals not conspicuous, recurved as in the other members of the *Turritella humerosa* group. Complete aperture not preserved.

Dimensions: Cotype, height, 43.5 mm; greatest diameter, 11.0 mm. Figured specimen, height, 60.0 mm; greatest diameter, 13.5 mm.

Type material: A number of cotypes in the James Hall collection of the Walker Museum of the University of Chicago; no. 24521. Figured specimen, U. S. Nat. Mus. no. 498012.

Type locality: "Six miles below Prairie Bluff, Alabama." Whitfield (1865, p. 266) cited this same locality in his description of "*Potamides alabamiensis*." This locality falls within the outcrop of the Midway, but there is no species in the Midway sediments with which *Turritella multilira* might be confused. In the discussion of *Mesalia alabamiensis* (see p. 327, I have pointed out the similarity between Whitfield's type of that species and the National Museum material from Bells and Greggs Landings, outcrops of the Tuscahoma sand. It is probable, however, that the type material of *Turritella multilira* came from Nanafalia Bluff, as the species is unknown in the Eastern Gulf province outside of the Nanafalia formation. It is quite possible that the types both of this species and of *Mesalia albamiensis* are from Nanafalia Bluff, as both forms are common in the sediments at that locality. Figured specimen, U. S. G. S. sta. 271, Nanafalia Bluff, Alabama River, Marengo County, Alabama. Wilcox group, Nanfalia formation.

Turritella multilira is known in the Eastern Gulf region only from the Nanafalia formation of Alabama, where it is the only representative of the *Turritella humerosa* stock. Though typical specimens may be readily distinguished from *Turritella bellifera* by their finer spiral threading, their sharper, but less prominently developed subsutural carinae, and their less strongly marked incrementals, the end members are less easily separated from the Tuscahoma form. In view of the characteristic stratigraphic distribution of the two species, however, the slight but constant differences are recognized in the taxonomy and Whitfield's name is here retained.

Specimens from the undifferentiated lower Eocene of Nuevo León, Mexico, are hardly distinguishable from the type material of *T. multilira*, and they have been tentatively placed with the Alabama forms. The Mexican material is not well preserved but the extremely fine liration of the adult whorls and the sharp, but not prominent, subsutural carinae closely resemble the sculpture of typical *T. multilira*. These Mexican forms are markedly different from the abundant *T. sanjuanensis* of the lower Eocene of Nuevo León in the configuration of the whorls, the sharpness of the subsutural carinae and the fineness of the spiral liration.

One of Whitfield's cotypes was generously loaned by the Walker Museum of the University of Chicago and is here figured. Whitfield never illustrated his species and, although both Harris and Cooke figured specimens of *T. multilira*, there is no published likeness of Whitfield's type material.

Distribution.—Wilcox group, Nanafalia formation. ALABAMA, *Wilcox County:* U. S. G. S. sta. 10766, new highway to Camden, 9.7 miles west of the town of Pineapple. *Marengo County:* U. S. G. S. stas. 271 and 5642, Nanafalia Bluff. *Pike County:* U. S. G. S. sta. 10777, Middle Elba road, 8 miles south of Troy in SE ¼ sec. 36, T. 9 N., R. 20 E.

Lower Wilcox group, undifferentiated. MEXICO, *Nuevo León:* U. S. G. S. sta. 13763, 275 meters from Rancho Paredita toward Rancho San Agustin.

TURRITELLA BELLIFERA Aldrich
Plate 34, figure 16

Turritella bellifera ALDRICH, *1885*, Cincinnati Soc. Nat. History, Jour., vol. 8, p. 150, pl. 3, fig. 13.—ALDRICH, *1886, ex parte*, Alabama Geol. Survey, Bull. 1, pp. 34, 55, 56, pl. 1, fig. 13 (Not p. 58 = *Turritella multilira* Whitfield.—ALDRICH, *1894, ex parte*, Alabama Geol. Survey, Rept. for 1894, p. 237 (Not p. 238 = *Turritella multilira* Whitfield nor pp. 130, 233 = *Turritella rina subrina* Palmer). Not SMITH and JOHNSON, *1887*, U. S. Geol. Survey, Bull, 43, pp. 29, 30 (= *Turritella rina subrina* Palmer).—Not CLARK, *1891*, U. S. Geol. Survey, Bull. 83, pp. 63, 64 (= *Turritella rina subrina* Palmer).—Not BRANTLY, *1920*, Alabama Geol. Survey, Bull. 22, p. 161 (= *Turritella rina subrina* Palmer).

Turritella (*Proto*) *cathedralis* Brogniart var. *bellifera* Aldrich. DEGREGORIO, *1890*, Faune éocénique de l'Alabama, p. 127, pl. 11, figs. 17, 38.

Turritella humerosa Conrad. HARRIS, *1900*, Louisiana Geol. Survey, Rept. for 1899 (Special Rept. 6), p. 308, pl. 55, fig. 5.

Turritella (*Haustator*) *bellifera* COSSMANN, 1912, Essais de paléoconchologie comparée, vol. 9, p. 118.

Spire high, slender, gradually tapering. Whorls flattened laterally, wider than high, separated by linear, distinct but not deeply impressed sutures. Earliest apical whorls not preserved; earliest whorl on type exhibiting four distinct, subequal, revolving lirae and two smaller, less distinct secondary

lirae; posterior primary cord gradually becoming relatively more prominent until on the seventh whorl of the type it forms a distinct subsutural keel, comparable to but distinct in form and manner of formation from that of *Turritella humerosa;* fine accessory lines constantly added until on the body whorl the six early lirae are augmented by numerous secondary threads variously placed between them. Incrementals deeply flexed between the posterior third and the median of the whorl, slightly reflexed just behind the anterior suture; especially prominent on the last two whorls although distinct over the whole spire. Aperture not preserved entire.

Dimensions: Holotype, height, 95.0 mm; greatest diameter, 18.5 mm.

Type material: A holotype in the collection of the Johns Hopkins University, Baltimore, Maryland.

Type locality: Lower stratum at Bells Landing, Alabama River, Monroe County, Alabama. Wilcox group, Tuscahoma sand.

Turritella bellifera differs from its northern analogue *Turritella humerosa*, of the Maryland and Virginia Aquia formation, in its coarser spiral sculpture and more angular subsutural carina. In *Turritella humerosa* the carina is formed by a thickening of the whorl just anterior to the suture, and the spiral sculpture continues unchanged over this thickened portion; in *T. bellifera* the posterior of the primary apical lirae gradually increases in size until it distinctly carinates the whorl, not nearly as sharply as in *T. praecincta* but much more so than in *T. humerosa*, s.s. *Turritella multilira* from the underlying Nanafalia beds differs from *T. bellifera* in its finer and more numerous revolving striae and its more pronounced subsutural carina.

Turritella bellifera is recorded with certainty only from the Tuscahoma sand of Alabama. Some poorly preserved specimens from the lower Wilcox beds of Pendleton, Sabine County, Texas, found in association with *T. postmortoni* and *T. praecincta* seem referable to this species and are placed tentatively with the Alabama material. The forms with straight-sided whorls and strong spiral sculpture found in deposits of Claiborne age and identified by Smith, Aldrich, Clark, Brantly and others as *T. bellifera* are referable to *T. rina subrina* Palmer.

Distribution.—Wilcox group, Tuscahoma sand. ALABAMA, *Choctaw County:* U. S. G. S. sta. 5472, Tuscahoma landing, Tombigbee River. *Dale County:* U. S. G. S. sta. 10769, Becks Mill, Pea River, 10 miles from Brundidge, sec. 7, T. 7 N., R. 23 E. *Wilcox County:* U. S. G. S. stas. 2669, 3098, 5593, 5594, 5595 and U. S. Nat. Mus. no. 1517, Bells landing, Alabama River; U. S. G. S. stas. 268, 2670, 3118, 5604, and 7479, Greggs Landing, Alabama River; U. S. G. S. sta. 5602, Lower Peachtree bluff, second fossil horizon, 60 feet from top, 80 feet from bottom, Alabama River. TEXAS, *Sabine County:* U. S. G. S. sta. ? 10743, Pendleton, Sabine River; U. S. G. S. sta. 11099, Sabine River, ¼ mile above Pendleton Ferry.

TURRITELLA PRAECINCTA Conrad
Plate 33, figure 11

Turritella praecincta CONRAD, *1864*, Acad. Nat. Sci. Philadelphia, Proc., ser. 2, vol. 8, p. 211.—HARRIS, *1897*, Bull. Am. Paleontology, vol. 2, no. 9, pp. 24, 29, 31.—HARRIS, *1899*, Bull. Am. Paleontology, vol. 3, no. 11, p. 76, pl. 10, fig. 8.—HARRIS, *1900*, Louisiana Geol. Survey, Rept. for 1899 (spec. rept. 6), p. 308, pl. 55, fig. 6.—GUILLAUME, *1924*, Soc. géol de France, Bull., sér. 4, vol. 24, p. 290.—COOKE, *1926*, Alabama Geol. Survey, Special Rept. no. 14, pl. 94, fig. 3.—GUILLAUME, *1926*, Soc. géol. France, Bull., sér. 4, vol. 26, p. 425.

Turritella (*Haustator*) *praecincta* CONRAD. COSSMANN, *1912*, Essais de paléoconchologie comparée, pp. 115, 118, pl. 7, fig. 13.

Shell large, very heavy. Spire gradually tapering. Whorls numerous, much wider than high, sharply carinated posteriorly in adult stages. Sutures linear and indistinct on the apical whorls, becoming more distinct with the development of the subsutural carina until on the adult whorls the sutures are deeply impressed and slightly overridden by the keel. Apical whorls marked by five revolving lirae, the posterior four equal in strength and equidistant from each other, the anterior lira stronger than the others and more distantly placed from them than they are from one another; a fine secondary line appearing between the two anterior lirae, on the fourth or fifth whorl; the posterior lira becoming rapidly more elevated after the eighth whorl until by the time the shell has attained its tenth volution there is a marked carination of the whorl immediately in front of the suture; a fine line appearing on the base of this carination at about the eleventh whorl; base of body

whorl marked by eight additional strong, revolving cords. Growth lines indistinct on the apical whorls becoming more prominent with the growth of the shell; deeply arcuate, the maximum retraction occurring at about the posterior third of the whorl. Complete aperture not observed. Base of body whorl marked by a thin parietal wash.

Dimensions: Holotype, "Length, 3⅜ inches; width of body whorl independent of carina ¾ inch" (Conrad, 1864.) Figured specimen, height, 92.3 mm; greatest diameter, 28.0 mm.

Type material: Holotype apparently lost; it could not be located in the Conrad collection of the Philadelphia Academy of Natural Sciences. Figured specimen, U. S. Nat. Mus. no. 497991.

Type locality: "Dallas Co.? Alabama" (Conrad, 1864). Figured specimen, U. S. G. S. sta. 260, Bells Landing, Alabama River, Monroe County, Alabama. Wilcox group, Tuscahoma sand.

Though *Turritella praecincta* is probably related to the group of *T. humerosa*, the extreme prominence of the subsutural carina makes this species distinct from any other in the Gulf Eocene. *T. praecincta* is known only from the Tuscahoma sand of Alabama and Georgia and the lower Wilcox of the Sabine Uplift region of East Texas.

Distribution.—Wilcox group, Tuscahoma sand. GEORGIA, *Clay County:* U. S. G. S. sta. 12018, old road, about 2 miles east of Days Crossroads, ¼ to ½ mile west of Fairview school, 9 miles north of Fort Gaines. ALABAMA, *Choctaw County:* U. S. G. S. sta. 5472, Tuscahoma Landing, Tombigbee River. *Dale County:* U. S. G. S. sta. 10769, Becks Mill, Pea River, about 10 miles from Brundidge, sec. 7, T. 7 N., R. 23 E. *Wilcox County:* U. S. G. S. stas. 260, 3098, and U. S. Nat. Mus. no. 90957, Bells Landing, Alabama River; U. S. G. S. stas. 268, 2670, 3118, 5604, and 7479, Greggs Landing, Alabama River; U. S. G. S. sta. 5602, Lower Peachtree Ferry, second fossil horizon, 60 feet from top, 80 feet from bottom, Alabama River.

TURRITELLA MCBEANENSIS Bowles, n. sp.
Plate 32, figures 17, 20

Shell small, heavy. Spire abruptly tapering in a series of steps formed by the overlapping of each whorl onto the preceding whorl. Whorls straight-sided, shouldered posteriorly; sutures linear but deeply impressed on the flat-topped upper surface of the prominent shoulders. Earliest apical whorls not preserved; first whorls present on the types exhibiting three rather strong subequal revolving lirae, equidistant from each other and symmetrically placed on the whorl; numerous inconspicuous secondary revolving threads, variously placed between the primaries and between them and the sutures; some of the secondaries rapidly increasing in size until the adult whorls are marked by five or six subequal, but not prominent, revolving cords. Incrementals indistinct, deeply arcuate, the maximum curvature attained at about the posterior third of the whorl, very slightly recurved at the anterior suture. Aperture not preserved entire.

Dimensions: Holotype, height, 22.0 mm; greatest diameter, 7.5 mm. Paratype, height, 17 mm; greatest diameter, 7.2 mm. Both the types are broken at the aperture and the apex.

Type material: A holotype, U. S. Nat. Mus. no. 497956 and a paratype, U. S. Nat. Mus. no. 497957.

Type locality: U. S. G. S. sta. 7816, Stroman's Mill, 5 miles east of Springfield, Orangeburg County, South Carolina. Claiborne group, McBean formation.

Turritella mcbeanensis is extremely reminiscent of the Midway and Wilcox members of the *Turritella humerosa* group. It most closely resembles *T. biboraensis* and *T. claytonensis* of the Midway, but it differs from them in the three strong revolving carinae, both the older species being marked by numerous fine subequal revolving lines. The angle of the spire is much less than that of *T. claytonensis*.

Distribution.—Claiborne group, McBean formation. SOUTH CAROLINA, *Orangeburg County:* U. S. G. S. sta. 7816, Stroman's Mill, 5 miles east of Springfield.

VI. INCERTAE SEDIS

TURRITELLA MINGOENSIS Bowles, n. sp.
Plate 32, figure 10

Turritella sp.? COOKE, *1936*, U. S. Geol. Survey, Bull. 867, p. 44 (only).

Spire high, very slender, 11 whorls in the holotype. First three apical whorls bare, a

distinct medial carina appearing on the fourth whorl; anterior to the primary carina the whorls are distinctly convex, but posterior to this carina they are smooth and concave in the apical region; a small indistinct carina appearing near the posterior suture at about the sixth whorl, never attaining a size comparable to that of the anterior carina but persisting to the body whorl; a small revolving line developed on the fifth whorl anterior to the primary carina, increasing with the growth of the shell and augmented by other indistinct revolving cords until on the body whorl there are five distinct lirae; very faint revolving lines appearing on the adult whorls posterior to the primary carina in some specimens, but on the type this area is bare except for the one posterior lira. Incrementals very faintly marked but indicating a strong sinuosity of the outer lip, the maximum retraction of the sinus situated a little behind the median of the whorl. Aperture not preserved entire on any of the specimens observed.

Dimensions: Holotype, height, 24.0 mm; greatest diameter, 6.2 mm.

Type material: A holotype, U. S. Nat. Mus. no. 497953.

Type locality: U. S. G. S. sta. 7976, bend in the road from Georgetown to Rhems at the boundary line between Georgetown and Williamsburg Counties, 1.2 miles south of Rhems and 3 miles northwest of Upper Brown's Ferry, Georgetown County, South, Carolina. Midway group, Black Mingo formation.

The slender form of this species, with the lower half of the whorls marked by revolving lines and convex, though the upper half is practically bare and concave, distinguish *Turritella mingoensis* from the other Gulf and Atlantic Eocene Turritellas. What the relationship of this unique species may be is uncertain, but it seems to have closer affinities with the group of *T. mortoni* than with the *T. humerosa* stock. Only a few specimens are known, and the species has been recorded only from the Black Mingo formation of South Carolina.

Distribution.—Midway group, Black Mingo formation. SOUTH CAROLINA, *Georgetown County:* U. S. G. S. sta. 7976, Bend in the county line road from Georgetown to Rhems, 1.2 miles south of Rhems and 3 miles northwest of Upper Brown's Ferry; U. S. G. S. sta. 7969, old ferry on the north bank of the Black River, just above the mouth of Choppee Creek, 12 miles N. 10° W. of Georgetown.

TURRITELLA OLA Plummer

Turritella ola PLUMMER, Univ. Texas, Bull. 3232, pp. 815, 816, pl. 10, fig. 2.—GARDNER, *1935*, Univ. Texas, Bull. 3301, p. 291.

Apical angle: 18.0°. Sculpture: 2 narrow, high spirals and faint posterior spiral line. Whorl shape: whorls separated by a fine, nearly invisible lira. (Plummer, 1933.)

Dimensions: Not given by Plummer. As indicated by the figure, the type is about 36 mm high.

Type material: Collections of the Bureau of Economic Geology, Austin, Texas.

Type locality: Quarry south of Ola, Kaufman County, Texas. Midway group, Kincaid formation.

Nothing conspecific with *Turritella ola* has been found in the collections of the U. S. National Museum. Miss Gardner (1935, p. 291) thinks that the individual figured by Plummer may be a juvenile.

TURRITELLA KINCAIDENSIS Plummer

Turritella kincaidensis PLUMMER, *1933*, Univ. Texas, Bull. 3232, pp. 815, 816, pl. 10, figs. 3, 3a.—GARDNER, *1935*, Univ. Texas, Bull. 3301, p. 285.

Apical angle: 12.5°. Sculpture: 14 finely beaded lirae. Whorl shape: convex with greatest diameter anterior. (Plummer, 1933.)

Dimensions: Not given by Plummer. As indicated by the figures, figure 3 is about 13 mm in height and figure 3a about 8 mm.

Type material: In the collections of the Bureau of Economic Geology at Austin, Texas.

Type locality: Figure 3 represents a specimen from the quarry south of Ola, Kaufman County, Texas; figure 3a, a specimen from one-fourth of a mile south of the mouth of Dry Creek, on the right bank of the Colorado River, Bastrop County, Texas. Midway group, Kincaid formation.

No specimens in the collections of the United States National Museum are referable to this species. Miss Gardner has suggested that some molds from U. S. G. S. sta. 11910, Cedar Creek, 3 miles (air line) south-

east of Williams' Store, Bastrop County, may be conspecific with *T. kincaidensis*, but the material is too poor to be determined with confidence. There is, however, a strong resemblance between Plummer's figure 3a and *Turritella hilli* Gardner, which was described from the Kincaid of the Colorado River section.

TURRITELLA LOWEI Cooke

Turritella lowei COOKE, *1926*, Washington Acad. Sci. Jour., vol. 16, no. 5, p. 136, fig. 9.

Shell small for the genus. Spire acute, rather abruptly tapering. Whorls rounded in the earliest stages, less inflated and straight-sided in the adolescent and adult stages, slightly carinated basally; separated by deeply incised sutures, linear between the apical whorls, slightly channelled between the adult. Apical whorls smooth; very fine, indistinct revolving lines first appearing about the fifth whorl, increasing but slightly in size with the growth of the shell; eight to ten of these indistinct revolving lirae on the body whorl, the two strongest situated nearest the anterior suture, slightly carinating the whorl basally; base of body whorl marked by six or seven additional indistinct fine revolving lines. Incrementals distinct but not prominent, slightly beading the fine posterior revolving lines at the intersections; strongly arcuate, the axis of the arc falling between the posterior third and the median of the whorl, very slightly reflexed just above the suture. Parietal wash heavy, distinct, but not covering a large area. Aperture subquadrate, about as high as wide. Outer lip thin, not preserved entire on any of the specimens studied.

Dimensions: Holotype, height, 23.0 mm; greatest diameter, 7.5 mm.

Type material: A holotype, U. S. Nat. Mus. no. 353945.

Type locality: U. S. G. S. sta. 4250, Moodys Branch, from the first bluff below the first bridge east of the Institution for the Blind, Jackson, Hinds County, Mississippi. Jackson group, Moodys marl.

Turritella lowei most closely resembles the associated form, *T. perdita* Conrad, but it differs from *T. perdita* in its smaller apical angle, its less distinct sculpture, and its more distinct and more deeply channelled sutures. It is with some hesitancy, however, that this species is recognized. The less strongly sculptured individuals of *Turritella perdita* closely approximate the type of *T. lowei* and it is only the end members of a long and apparently continuous series that are separable. Since the name is already in the literature it is retained for these slightly sculptured individuals.

Turritella lowei has been recorded only from the Moodys marl at Jackson and synchronous beds on Garlands Creek near Shubuta, Clarke County, Mississippi, and is not common at either of these localities. It never attains the size of the largest specimens of *Turritella perdita*, but the forms appear to be fully adult.

Distribution.—Jackson group, Moodys marl. MISSISSIPPI, *Hinds County:* U. S. G. S. sta. 58, Green's marl bed, Jackson; U. S. G. S. sta. 3734, south of pump house, Jackson; U. S. G. S. sta. 4250, Moodys Branch, from the first bluff below the first bridge, east of the Institution for the Blind, Jackson; U. S. G. S. sta. 6458, Moodys Branch, SW ¼ sec. 35, T. 6 N., R. 1 E. *Clarke County:* U. S. G. S. sta. 6471, Bluff on Garlands Creek, about 100 feet below the bridge on the road to Quitman, about 5 miles northeast of Shubuta.

Genus MESALIA Gray, 1842

Mesalia GRAY, *1840*, Synopsis Contents British Museum, 42nd ed., p. 147 (nomen nudum).—GRAY, *1842*, idem, 44th ed., p. 61 (valid genus without species).—GRAY, *1847*, Zool. Soc. London, Proc. for 1847, p. 155.—JEFFREYS, *1884*, Zool. Soc. London, Proc. for 1884, p. 132.—COSSMANN, *1912*, Paléoconchologie comparée, vol. 9, p. 124.—IREDALE, *1913*, Malacol. Soc. London, Proc., vol. 10, pp. 296, 305, 306 (Gray, 1842, reprinted).—SMITH, *1915*, Ann. and Mag. Nat. History, 8th ser., vol. 15, pp. 366–367.

Genotype by original designation: *Cerithium mesal* Adanson = *Turritella mesal* Deshayes = *Turritella brevialis* Lamarck. Recent off the north coast of Africa.

Spire elongate, more rapidly tapering than in *Turritella;* whorls rounded and often highly inflated; sutures distinct but not channelled or deeply impressed; aperture subcircular, slightly reflected anteriorly; outer lip entire; sculpture absent or consisting of revolving striae of varying size, sometimes modified into distinct carinations of the whorls; incremental striae simple,

gently arcuate, meeting the anterior suture almost directly below their contact with the posterior suture; operculum paucispiral, consisting of

> four or five rapidly increasing volutions, somewhat carinate at the suture toward the deep nucleus, and with a raised spiral thread upon them which does not extend to the last two large whorls. (Smith, 1915.)

Jeffreys (1884) cited *Turritella sulcata* Lamarck, of the Paris Eocene, as the type of *Mesalia* Gray. Smith (1915) disagreed with Jeffrey's designation, but apparently he did not recognize Gray's original citation of *Cerithium mesal* as a valid type designation, basing his objection to *T. sulcata* on the obvious intent of Gray in naming his genus *Mesalia* after *Turritella mesal* Deshayes (*Cerithium mesal* Adanson, 1757). *Mesalia*, however, is not a strictly tautonomous name, and the genotype cannot be so determined. In his text Gray (1847) distinctly states

> The method I have followed is to observe the first name given to the genus and the type on which it was founded, and then to accumulate the synonyms around the genus. Where a succeeding author has referred to a different species as the type of the genus, I have given the name in a new line, as at some future period that type may be proved really to belong to the before-established genus, it is in a similar manner placed under the proper head, with the synonym belonging to that type.

In his reference to the genus on page 155 Gray lists "Mesalia, *Gray*, 1840; 1844, 60. Cerithium Mesal *Adans.* 1757. Turritella Mesal, *Desh.*" and then on the *next* line, as his synonymy, he lists "Turritella, sp. *Lam.* Tur. sulcata, Lam." Smith considered the genus as containing three species, *Cerithium mesal* Adanson = *Turritella mesal* Deshayes, a *Turritella* sp., and *T. sulcata* Lamarck. Apparently Smith overlooked the critical position of the comma after "*Turritella*" and before "sp." in Gray's citation, a punctuation that indicates that Gray is assigning part of the genus *Turritella* as used by Lamarck to *Mesalia* with *T. sulcata* Lamarck representing this group of Lamarckian Turritellas. Stewart (1927, p. 353) has apparently accepted this interpretation without question. The fact that Adanson is rejected because he was pre-Linnaean, and *Turritella mesal* Deshayes, 1843, is a synonym of *Turritella brevialis* Lamarck, 1822, has no effect on the validity of Gray's genotype designation.

Mesalia may be confused only with *Turritella*, from which it differs principally in the slight recurving of the anterior portion of the lip. The incremental striae of *Mesalia* are simple arcs, meeting the posterior suture almost directly above their junction with the anterior suture, whereas in *Turritella* the growth lines are more or less strongly flexed and recurved, recording a sinuosity of the old lip margin, which in some species, notably those comprising the section *Colpospira* of Miss Donald (1900, p. 51) (Mrs. Longstaff) is a narrow and deeply incised sinus approaching that of the Paleozoic Murchisoniidae. The spire of *Mesalia* is usually much more abruptly tapering than that of *Turritella*, and the whorls are more rounded. The paucispiral operculum of *Mesalia* as contrasted with the multispiral operculum of *Turritella* has little value in a separation of the fossil forms, although it is a very valuable criterion in systematic studies of the Recent faunas.

The genus first appears in North America in the Eocene, although the group is apparently foreshadowed in the Cretaceous of other parts of the world. Grabau and Shimer (1909, p. 730) refer *Turritella seriatimgranulata* and *T. belviderei* of the Texan and Kansan Comanchean to the subgenus *Mesalia*, but these species are totally distinct and belong in *Turritella*, s.s.

Arcotia indica Stoliczka (1867–68) of the Indian Cretaceous seems referable to this genus and was placed in the synonymy by Cossmann and questionably by Stewart. The sharply angulated whorls are quite similar to those of *M. hardemanensis* Gabb of the upper Midway of the Gulf and *M. martinezensis* Gabb of the California Paleocene. Stewart has suggested that Stoliczka's name *Arcotia* might be useful for strongly angulated species, but this character, as he pointed out, is too variable to merit superspecific recognition. Fischer (1887, p. 694) doubtfully referred *Arcotia* to *Turritella* as a subgenus.

The genus *Lithotrochus* Conrad (1855, p. 283), referred by Cossmann (1912, pp. 125, 126) and Moericke, (1895, p. 27) to *Mesalia*, is a very distinct group of trochoids.

The genotype comes from the Jurassic of Chile. Cossmann (1918, p. 276) later placed *Lithotrochus* under his genus *Proconulus*.

Douvillé (1904, 1929) has recorded *Mesalia fasciata*, described by Lamarck from the Eocene of the Paris Basin, from the Danian of Persia and India. The figures of these forms certainly indicate a close relationship with the Parisian species, although in the case of the Indian material several species seem to be represented. Vredenburg (1928, p. 59) and Cox have very interesting discussions of the variations of *M. fasciata* from the Danian through the middle Eocene of India.

White (1888) described two species of *Mesalia*, *M. nettoana* and *M. hebe*, from the supposed Cretaceous of Brazil. The Maria Farinha beds, from which *M. nettoana* was described, are now however, recognized as lower Eocene. *M. hebe* was described from São Gonçalo in the state of Sergipe, and the position of the strata in which it is found is in question. It may well prove to be lower Eocene.

Mesalia reached the apex of its development in the Eocene. Numerous species have been described from the Eocene throughout the world, and their representation in the Gulf and Atlantic Coastal Plain is extensive, although only one species, the Paleocene form *M. martinezensis*, has been recorded from the west coast of this country. The group became much more restricted in distribution toward the end of the Eocene, and at the close of the period again disappeared from North American waters. Few species are recorded from the post-Eocene of the rest of the world. Smith (1915) reports only six species of *Mesalia* in the Recent faunas, these occurring in West Australia, the Mediterranean, the Atlantic coast of France and the Iberian Peninsula, and east Africa.

In the Midway of the Gulf Embayment and Atlantic Coastal Plain five species of *Mesalia* are recorded. These represent two distinct lines of development. In the lower Midway Clayton formation of Mississippi, Tennessee and Alabama, and the Kincaid formation of Texas, the three species of *Mesalia* recognized, *M. pumila*, *M. wilcoxiana*, and *M. mavericki*, are all characterized by numerous revolving cords on the adult whorls, and the whorls of these species are all more or less rounded. A related form, *M. gomin*, is restricted to the Black Mingo formation of South Carolina, a formation probably of Midway age.

The second group of Midway Mesalias is characterized by a strong median carination of the whorls. This group is not represented in the lower Midway, appearing first in the upper Midway Porters Creek clay of Mississippi and Tennessee, where it is represented by the single species *M. hardemanensis*. An analogous species, *M. sayi*, is found in the lower Eocene deposits of Nuevo León in Mexico. These two eastern species are apparently closely related to the *M. martinezensis* of the California Paleocene. The members of this carinate group are nowhere abundant, and they disappear with the close of the lower Eocene.

In the Wilcox group of Alabama the *M. wilcoxiana* group is represented by the extremely abundant *M. alabamiensis* from the Nanafalia and Tuscahoma formations and *M. biplicata*, restricted to the Nanafalia. Though only these two species are recorded, their abundance makes *Mesalia* one of the dominant genera of the lower Wilcox. No Mesalias have been recorded from the lower Wilcox of the Sabine Uplift region of East Texas, although several of the abundant Nanafalia and Tuscahoma species of *Turritella* are well represented.

There are no members of the genus in deposits of upper Wilcox age, and their absence is rendered even more striking by the fact that with the advent of the Claiborne, the group of *M. wilcoxiana* reappears although with just a single, very widespread species. *M. claibornensis* is found in deposits of Claiborne age from Mexico through Georgia, and is one of the most common fossils of this horizon. There is a great deal of variation in this species, and some of the variants seem to be constant enough to have certain stratigraphic significance, although not recognizable taxonomically. Renick and Stenzel (1931a) have pointed out this variation in their analysis of the Crockett faunas in the region of the Brazos River in Texas. The *wilcoxiana-alabamiensis-claibornensis* line of development is carried into the Jackson epoch, where *M. vetusta* and *M. georgiana* mark a continuation of the race. Like *M. claibornensis*, *M. vetusta* is very

abundant, although its stratigraphic and geographic range is limited to the Moodys marl of Alabama.

The robust species *M. georgiana* from the Barnwell sand of Georgia is allied to *M. vetusta*, and probably likewise is a descendant of the multistriate group, although on its adult whorls the striations are extremely fine and indistinct.

MESALIA WILCOXIANA (Aldrich)
Plate 34, figures 2, 3, 4

Turritella wilcoxiana ALDRICH, *1894*, Alabama Geol. Survey, Rept. for 1894, p. 247, pl. 13, fig. 4b.

Turritella allentonensis ALDRICH, *1894*, Alabama Geol. Survey Rept. for 1894, pp. 246, 247, pl. 13, figs 4a, 6.

Mesalia watsonensis HARRIS, *1896*, Bull. Am. Paleontology, vol. 1, no. 4, p. 228, pl. 12, fig. 2.—COSSMANN, *1912*, Essais de paléoconchologie comparée vol. 9, p. 126.—ALDRICH, *1921*, Bull. Am. Paleontology, vol. 9, no. 37, p. 26.

Mesalia pumila var. *allentonensis* HARRIS, *1896*, Bull. Am. Paleontology, vol. 1, no. 4, p. 113, pl. 11, figs. 20, 21. Not MAURY, *1912*, Acad. Nat. Sci. Philadelphia, Jour. 2d ser., vol. 15, pp. 29, 97, 98, pl. 12, fig. 27 (=n. sp.?), nor HARRIS, *1926*, Johns Hopkins Univ., Studies in Geology, no. 7, p. 100 (=n. sp.?).

Mesalia pumila var. *wilcoxiana* HARRIS, *1896*, Bull. Am. Paleontology, vol. 1, no. 4, p. 112, pl. 11, figs. 16, 17.—DEUSSEN, *1914*, U. S. Geol. Survey, Water-Supply Paper 335, pp. 32, 35. Not TROWBRIDGE, *1923*, U. S. Geol. Survey, Prof. Paper 131-D, p. 89. (= *Mesalia mavericki* Gardner.)

Mesalia (*Mesalia*) *pumila wilcoxi* Aldrich. COSSMANN, *1912*, Essais de paléoconchologie comparée, vol. 9, p. 126.

Mesalia pumila (Gabb). STEPHENSON and CRIDER, *1916*, U. S. Geol. Survey, Water-Supply Paper 399, pp. 52, 53. (Not *Mesalia pumila* (GABB), 1860.)

Mesalia wilcoxiana (Aldrich). GARDNER, *1935*, Texas Univ., Bull. 3301, p. 295.

Spire high, abruptly tapering. Whorls rounded and highly inflated; sutures distinct and deeply impressed. Sculpture consisting of two very large, coarse, revolving cords medially situated on the early whorls (the earliest whorls are unknown), with a less pronounced cord between them and the posterior suture, arising on the third or fourth whorl and becoming progressively stronger on the later whorls; entire surface of whorls threaded by very fine revolving lirae, which are especially evident on slightly decorticated individuals. Aperture unknown. Incrementals strongly marked, gently and symmetrically arcuate, occasionally slightly beading the spiral threading.

Dimensions of holotype: Height, 23.0 mm; greatest diameter, 13 mm. The holotype is a very incomplete individual with only about 2½ whorls remaining.

Type material: Holotype of *M. wilcoxiana* and holotype and paratype of *M. allentonensis* in the Aldrich collection of the Johns Hopkins University. Holotype of *M. watsonensis* in the Paleontological Research Institution, Ithaca, New York.

Type locality: "Turritella rock near Prairie Creek, Wilcox County, Alabama" (Aldrich, 1894).

The types of *M. wilcoxiana* and *M. allentonensis* are the specimens figured. The type of *M. watsonensis* was studied in the collection of the Paleontological Research Institution through the courtesy of Doctor Gilbert D. Harris.

In slightly decorticated individuals the large revolving cords are not obvious, and the numerous small revolving lines comprise the chief sculpture. It was such an individual that Aldrich described from Allenton under the name *Turritella allentonensis*. The smaller specimen that he figured under this name exhibits the characteristic cords much better than does the type, and, although immature, it is much better preserved and more complete than the holotypes of either *M. allentonensis* or *M. wilcoxiana*. Harris (1896) described *M. watsonensis* from a locality near Clayton in Barbour County Alabama. This species was described from a mold only, and it is apparently only a young specimen of *M. wilcoxiana* very similar to the paratype of *M. allentonensis*.

M. wilcoxiana can be confused only with *M. mavericki* Gardner of the Texas Midway. It differs from the Texas form in the less-marked inflation of its whorls, and in the more gradual tapering of its spire. The revolving cords of *M. mavericki* are more concentrated on the median portion of the whorl than are those of *M. wilcoxiana*. Both these species are very large, larger than any of the other representatives of the genus in the Gulf Eocene or Paleocene.

In 1912 Miss Maury referred a specimen from the Soldado beds of Trinidad to *M. allentonensis*, but the figure given seems to indicate a distinct species. The Trinidad

form is marked by four subequal revolving cords, and the sculpture attains a regularity not seen in the rather poorly preserved material from Alabama. Harris' reference to "*Mesalia pumila* var. *allentownensis* (Aldrich)" in his discussion of the Midway fauna of Trinidad in 1925 probably applies to this new species(?) figured by Miss Maury.

M. wilcoxiana is nowhere common, but it is represented in the collections of the National Museum and the Johns Hopkins University from Alabama, South Carolina, Mississippi, and Arkansas. The South Carolina material is not well preserved, and the Mesalias are placed under *M. wilcoxiana* very tentatively. The specimen from U. S. G. S. sta. 7399, however, exhibits the typical fine striation of the adult whorls, superimposed on the coarser cords that are a continuation of the earlier sculpture. This specimen closely resembles Aldrich's paratype of *M. allentonensis*. The specimens in the National Museum collection from Jackson County, Arkansas, were referred by Stephenson and Crider to *M. pumila* (Gabb).

Harris (1896, p. 112) records the species from 1 mile up Salt Branch of the Little Brazos River, and from Tehuacana, Texas, but neither Gardner nor Plummer have reported it from Texas.

Distribution.—Undifferentiated Midway group. SOUTH CAROLINA, *Clarendon County:* U. S. G. S. sta. 7964, Tindall's old mill, road from Manning to Paxville, 6 miles west of Manning. U. S. G. S. sta. 10403, Kingstree road, east of Deep Creek, 5 miles east of Manning. *Williamsburg County:* U. S. G. S. sta. 7920, roadside, 1.1 miles south of Salters. ARKANSAS, *Jackson County:* U. S. G. S. sta. 6324, cut of St. Louis, Iron Mountain and Southern Railway, one-fourth mile southwest of Grandglaise.

Midway group, Clayton formation. ALABAMA, *Wilcox County:* U. S. G. S. sta. 264, Prairie Creek. MISSISSIPPI, *Pontotoc County:* U. S. G. S. sta. 7399, deeply weathered ferruginous red sand, in gully west of south end of the deep cut, one-half mile south of Pontotoc.

MESALIA MAVERICKI Gardner

Meslia pumila subsp. *wilcoxiana* Aldrich. TROWBRIDGE, *1923*, U. S. Geol. Survey, Prof. Paper 131-D, p. 89.

Mesalia mavericki GARDNER, *1935*, Univ. Texas, Bull. 3301, pp. 295, 296, pl. 25, figs. 7, 8.

Mesalia sp. cf. *M. mavericki* GARDNER, *1935*, Univ. Texas, Bull. 3301, p. 296, pl. 25, fig. 9.

Spire abruptly tapering. Whorls inflated, sharply constricted at the sutures, which are well-defined and deeply impressed. Sculpture consisting of two very strong raised revolving cords on the medial portion of the apical whorls, with a less prominent cord between them and the posterior suture appearing on about the third whorl and gradually becoming stronger until on the youngest whorl it is only a little less prominent than the two primary cords; entire surface of whorls marked by very fine, regularly spaced revolving lines, which are fairly strong on the last two whorls. Incrementals simple, arcuate, cutting the anterior suture just a little behind their intersection with the posterior suture. Aperture unknown.

Dimensions: Holotype, height, 20.0 mm; greatest diameter, 17.5 mm. Paratype, height, 32.0 mm; greatest diameter, 17.5 mm.

Type material: Holotype, U. S. Nat. Mus. no. 370944; paratype, U. S. Nat. Mus. no. 494989.

Type locality: U. S. G. S. sta. 11754, 6 miles south of the McFarland sheep pens and 27 miles southeast of Eagle Pass, Maverick County, Texas.

The specimen that Miss Gardner described and figured as *Mesalia* sp. cf. *M. mavericki* Gardner represents the young whorls of this species, and exhibits the same dominantly bicarinate sculpture so characteristic of the younger whorls of *M. wilcoxiana* (Aldrich) of the Alabama Midway. *M. mavericki* differs from its northeastern analogue, however, in its more rapidly tapering spire and in the more medially concentrated sculpture on both the younger and older whorls.

Distribution.—Midway group, Kincaid formation. TEXAS; *Maverick County:* U. S. G. S. sta. 11754, 6 miles south of the McFarland sheep pens and 27 miles southeast of Eagle Pass. *Falls County:* U. S. G. S. sta. 11940, Stranger School, 7.5 miles northwest of Kosse.

MESALIA PUMILA (Gabb)

Plate 34, figure 7

Turritella pumila GABB, *1860*, Acad. Nat. Sci. Philadelphia, Jour., 2d ser., vol. 4, p. 392, pl.

68, fig. 14. Not JOHNSON, *1905*, Acad. Nat. Sci. Philadelphia, Proc., vol. 57, pl. 21 (= *Turritella encrinoides* Morton).—Not WELLER, *1907*, New Jersey Geol. Survey, Paleontology, vol. 4, pp. 694, 695 (= *Turritella encrinoides* Morton).—Not WHITFIELD, *1891*, U. S. Geol. Survey, Mon. 18, p. 187, pl. 23, figs. 5, 6 (= *Turritella encrinoides* Morton).

Potamides alabamiensis Whitfield. ?HARRIS, *1894*. Arkansas Geol. Survey, Ann. Rept. for 1892. vol. 2, p. 30. Not WHITFIELD, *1865*.

Mesalia pumila HARRIS, *1896*, Bull. Am. Paleontology, vol. 1, no. 4, p. 112, pl. 11, fig. 15.—Not STEPHENSON and CRIDER, *1916*, U. S. Geol. Survey, Water-Supply Paper 399, pp. 52, 53 (= *Mesalia wilcoxiana* (Aldrich)).

Mesalia alabamiensis (Whitfield). HARRIS, *1896*, Bull. Am. Paleontology, vol. 1, no. 4, p. 17 (not pp. 35, 113, pl. 12, fig. 1).—VEATCH and STEPHENSON, *1911*, Georgia Geol. Survey, Bull. 26, p. 223.—STEPHENSON and VEATCH, *1915*, U. S. Geol. Survey, Water-Supply Paper 341, p. 69.

Mesalia (*Mesalia*) *pumila* (Gabb). COSSMANN, *1912*, Essais de paléoconchologie comparée, vol. 9, p. 126.

Mesalia pulima (Gabb). (Typographical error.) STEWART, *1927*, Acad. Nat. Sci. Philadelphia, Proc. for 1926, vol. 78, p. 354.

Spire high, rather abruptly tapering, although not expecially so for the genus. Whorls numerous, rounded, sharply constricted at the linear sutures. Sculpture consisting of two rather prominent revolving cords on the earliest whorls, with accessory revolving cords appearing both anterior and posterior to them on the fourth to the seventh whorls; secondary sculpture increasing rapidly in prominence until on adult whorls it is hardly distinguishable in degree of elevation from the two primary words. Total number of revolving cords on the adult whorls variable, ranging from five to eight in a rather limited suite of specimens. Growth lines simple, gently arcuate, not reflexed. Aperture unknown.

Dimensions: Holotype: "Length of fragment .5 in., width of body whorl .3 in., diameter of mouth .1 in." (Gabb, 1860). Figured specimen, height, 12.5 mm; greatest diameter, 5.0 mm.

Type material: Holotype apparently lost; it is not in the Gabb collection of the Academy of Natural Science in Philadelphia, nor in Professor Safford's collections at Vanderbilt University. Figured specimen: U. S. Nat. Mus. no. 497984.

Type locality: "Hardeman Co., Tenn." (Gabb, 1860.) Figured specimen: U. S. G. S. sta. 284, Prairie Creek, Wilcox County, Alabama. Midway group, Clayton formation.

There is no material in the collections of the National Museum from Tennessee referable to this species. Most of the Tennessee collections are very poor and very incomplete, and further collecting might bring to light some specimens of *Mesalia pumila*. There are some small Mesalias, however, from the Clayton formation of Alabama that seem to belong here. They are very small, although no smaller than the dimensions given by Gabb. None of them have the adult aspect of the other Mesalias from the same horizon, and it is quite possible that their small size is due merely to their immaturity. *Mesalia pumila* has always been the collecting ground of Midwayan Mesalias of somewhat uncertain relationships, and the Alabama forms are placed here more or less following that tradition. The specimens from Georgia, represented only by molds, match very well both with the Alabama forms and with Gabb's original description, although they are somewhat larger.

The imperfectly preserved Mesalias from Arkansas listed by Harris (1894) as *Potamides alabamiensis* Whitfield are probably referable to *Mesalia pumila*, although their specific identity is obscured by their poor state of preservation The material discussed by Harris is in the National Museum.

Distribution.—Midway group, Clayton formation. ALABAMA, *Wilcox County:* U. S. G. S. sta. 264, Prairie Creek; U. S. G. S. sta. 283, Black Creek Branch of Prairie Creek; U. S. G. S. sta. 284, Prairie Creek and Pine Barren section.

Undifferentiated Midway group. GEORGIA, *Webster County:* U. S. G. S. sta. 5483, limestone at Lime Spring, Cole Property, 2 miles southeast of Preston. ARKANSAS, *Pulaski County:* U. S. G. S. sta. ? 2218, Dr. Johnson's well, top of Capitol Hill, corner of Battery and 9th Streets, Little Rock; U. S. G. S. sta. ? 2433, about 1.5 miles northeast of Alexander, NW ¼ SE ¼ sec. 8, T. 1 S., R. 13 W.

MESALIA GOMIN Bowles, n. sp.
Plate 33, figure 9

Mesalia? n. sp.? COOKE, *1936*, U. S. Geol. Survey, Bull. 867, p. 51.

Shell small; spire abruptly tapering. Whorls (only four preserved on the holotype) inflated, angulated somewhat by the prominent revolving carinae. Sculpture the same on all the whorls preserved, consisting of three prominent revolving carinae, the posterior one less pronounced than the two subequal anterior; fine revolving lines are also present over the surface of the whorls, but they are obscured by the prominent overriding growth lirae. Incrementals simple arcs, strongly marked. Outer lip not preserved.

Dimensions: Holotype, height, 12.5 mm; greatest diameter, 7.5 mm. The holotype is broken both at the apex and the aperture.

Type material: Holotype, U. S. Nat. Mus. no. 497954.

Type locality: U. S. G. S. sta. 7983, roadside, 2 miles west of Catchall, Sumter County, South Carolina. Midway group, Black Mingo formation.

This species differs from *Mesalia alabamiensis* (Whitfield) of the Alabama Wilcox in the persistence of the three prominent revolving lirae on the adult whorls. *M. alabamiensis* exhibits three revolving cords on the earliest apical whorls, but others are added early and the adult whorls are characteristically marked by four or five prominent subequal revolving carinae. The other lower Wilcox form of Alabama, *M. biplicata*, differs from *M. gomin* in the persistence of only two of the apical ribs onto the adult whorls. *M. wilcoxiana* and *M. mavericki* of the lower Midway are more robust forms with stronger cords, and with fairly prominent secondary sculpture on the adult whorls.

The type is unique. Such an incomplete specimen would not have been named were it not for the consistently poor state of preservation of all the Black Mingo material from South Carolina, and the distinctive sculpture of the few whorls preserved.

MESALIA ALABAMIENSIS (Whitfield)
Plate 34, figure 10

Potamides alabamiensis WHITFIELD, *1865*, Am. Jour. Conchology, vol. 1, p. 266, pl. 27, fig. 13.—DEGREGORIO, *1890*, Faune éocénique de l'Alabama, p. 124, pl. 11, fig. 12.—DALL, *1892*, Wagner Free Inst. Sci., Trans., vol. 3, pt. 2, p. 287. Not HARRIS, *1894*, Arkansas Geol. Survey, Ann. Rept. for 1892, pp. 26, 29, 30, 46 (= *Mesalia pumila* Gabb). Not STEPHENSON and CRIDER, *1916*, U. S. Geol. Survey, Water-Supply Paper 399, pp. 49, 53 (=sp.?).

Mesalia alabamiensis HARRIS, *1897*, Bull. Am. Paleontology, vol. 2, no. 9, pp. 25, 31 (on p. 25 as *Potamides*).—COOKE, *1926*, Alabama Geol Survey, Spec. Rept. 14, p. 264, pl. 94, fig. 9.—PALMER, *1937*, Bull. Am. Paleontology, vol. 7, no. 32, p. 204. Not HARRIS, *1896*, Bull. Am. Palentology, vol. 1, no. 4, pp. 17, 35, 113, pl. 12, fig. 1 (= *Mesalia pumila* Gabb). Not VEATCH and STEPHENSON, *1911*, Georgia Geol. Survey, Bull. 26, p. 223 (= *Mesalia pumila* Gabb). Not DEUSSEN, *1914*, U. S. Geol. Survey, Water-Supply Paper 335, pp. 32, 36 (=sp.?).—Not STEPHENSON and VEATCH, *1915*, U. S. Geol. Survey, Water-Supply Paper 341, p. 69 (= *Mesalia pumila* Gabb).

Mesalia pumila var. *alabamiensis* HARRIS, *1899*, Bull. Am. Paleontology, vol. 3, no. 11, pp. 76, 77, pl. 10, fig. 9.

Mesalia (*Mesalia*) *alabamiensis* (Whetfield). COSSMAN, *1912*, Essais de paléoconchologie comparée, vol. 9, p. 126.

Spire abruptly tapering; whorls very inflated, rounded and sharply constricted at the sutures, which are well-defined but not deeply impressed. Apical whorls characteristically marked by three equally-spaced, subequal revolving cords, a secondary cord appearing between the posterior primary rib and the posterior suture on the third or fourth whorl, increasing in size with the growth of the shell until all four ribs are subequal on the last whorl; an additional cord occasionally appearing on the early whorls between the anterior primary cord and the anterior suture, in which case the last whorls are sculptured by five equally strong spiral ribs; base of the body whorl bearing five or six additional spiral cords. Lines of growth rather indistinct except near the aperture; simple, only slightly arcuate. Aperture rounded; parietal callus pronounced; anterior margin of orifice slightly reflected.

Dimensions: "Length of shell 1.12 inches, transverse diameter of body whorl .45 inch" (Whitfield, 1865). Cotype: height, 26.0 mm; greatest diameter, 12.0 mm.

Type material: A number of cotypes in the Hall Collection of the Walker Museum of the University of Chicago, no. 24520.

Type locality: "Six miles below Prairie Bluff, Alabama." (Whitfield, 1865.) The type locality is probably not at Matthews Landing as the locality cited by Whitfield would indicate. There are no specimens ap-

proaching this species in form or size in the extensive collections of Midway age in the National Museum, and the cotype exactly resembles, both in the form of preservation and in the specific characters, the large numbers of Mesalias in the collections from Bells and Greggs Landings. Aldrich (1887, p. 81) has pointed out the inaccuracy of Whitfield's localities and it would be reasonably safe to assume that this species was described from Nanafalia or Tuscahoma material, more probably the latter, rather than from material of Midway age.

One of Whitfield's syntypes was kindly loaned by the Walker Museum of the University of Chicago and is the specimen figured.

Mesalia alabamiensis is one of the most abundant forms in the deposits at Bells and Greggs Landings on the Alabama River. The species is closely related to *M. pumila* (Gabb) of the Midway, but it is generally larger, more inflated and with more numerous revolving cords on the adult whorls. *M. gomin* of the Black Mingo formation of South Carolina is characterized by three large persistent carinae on each whorl instead of the four or five of *M. alabamiensis*. *M. biplicata*, with which it is associated in the Nanafalia, may be readily distinguished by the persistence of bicarinate sculpture on both the apical and adult whorls.

Distribution.—Wilcox group, Nanafalia formation. ALABAMA, *Marengo County:* U. S. G. S. stas. 271 and 5642, Nanafalia Bluff, Tombigbee River.

Wilcox group, Tuscahoma formation. ALABAMA, *Wilcox County:* U. S. G. S. sta. 10782, Yellow Bluff, Alabama River; U. S. G. S. stas. 5602 and 10779, Lower Peachtree Ferry, Alabama River. *Monroe County:* U. S. G. S. stas. 2669, 3098, 5593, 5594, 5595 and U. S. Nat. Mus. nos. 90959 and 113374, Bell's Landing, Alabama River; U. S. G. S. stas. 269, 2670, 3118, 5604, Gregg's Landing Alabama River.

MESALIA BIPLICATA Bowles, n. sp.
Plate 34, figures 6, 8

Spire abruptly tapering; whorls rounded, inflated, numerous; sutures distinct but not sharply impressed. Apical whorls marked by two strong revolving cords, on the third or fourth whorl a much less pronounced secondary rib appearing between the posterior primary cord and the posterior suture, and a second indistinct cord appearing a little later between the anterior primary cord and the anterior suture. Unlike the secondary sculpture of *M. alabamiensis* these secondary lirae do not increase materially in size, the adult whorls being strongly bicarinate like the apical. Base of the body whorl marked by five additional strong revolving cords. Incrementals distinct, simple, arcuate, cutting the anterior suture almost directly below their intersection with the posterior suture. Aperture subcircular, the anterior edge of the lip slightly reflected.

Dimensions: Holotype, height, 28.5 mm; greatest diameter, 13.3 mm. Paratype, height, 22.0 mm; greatest diameter, 19.0 mm.

Type material: Holotype, U. S. Nat. Mus. no. 494990. Paratype, U. S. Nat. Mus. no. 494991.

Type locality: U. S. G. S. sta. 271, Nanafalia Bluff, Marengo County, Alabama. Wilcox group, Nanafalia formation.

Mesalia biplicata differs from *M. alabamiensis* in the persistence of its bicarinate sculpture. The sculpture of *M. alabamiensis* is variable within restricted limits, but the adult whorls always bear either four or five strong, subequal, revolving cords, none of which is as prominent as the two sharp carinations of *M. biplicata*. The early whorls of *M. alabamiensis* exhibit three equal lirae, but the apical whorls of the subspecies have only two.

Distribution.—Wilcox group, Nanafalia formation. ALABAMA, *Marengo County:* U. S. G. S. stas. 271 and 5641, Nanafalia Bluff, Tombigbee River. *Pike County:* U. S. G. S. sta. 10765, Three Notch Road, middle of section 17, T. 8 N., R. 20 E., one-fourth of a mile northeast of Henderson.

MESALIA CLAIBORNENSIS Harris
Plate 34, figure 5

Mesalia vetusta Conrad. ALDRICH, *1886*, Alabama Geol. Survey, Bull 1, p. 46.—ALDRICH, *1894, ex parte*, Alabama Geol. Survey, Rept. for 1894, p. 233.—MCCALLIE, *1908, ex parte*, Georgia Geol. Survey, Bull. 15, p. 337 (Not pp. 338, 340–342, 346, 347, *Mesalia georgiana* Bowles; nor pp. 345, 348, *Mesalia* sp.?).—VEATCH and STEPHENSON, *1911*, Georgia Geol. Survey, Bull. 26, pp. 246, 256, 258, 259, 276, 278, 282, 295 (Not pp. 286, 289, 292, *Mesalia*

georgiana Bowles).—?BRANTLY, *1916*, Georgia Geol. Survey, Bull. 21, p. 19.

Turritella (*Mesalia*) *claibornensis*, HEILPRIN, *1891*, Acad. Nat. Sci. Philadelphia, Proc. for 1890, p. 400 (nomen nudum).

Messalia venusta Conrad. KENNEDY, *1892*, Texas Geol. Survey, 3d Ann. Rept., p. 57. (Not *Melania? vetusta* Conrad, 1833. The specific name was first misspelled "*venusta*" by Conrad himself in 1865, and this error is very common in the literature.)

Mesalia calibornensis, DUMBLE, *1894*, Jour. Geology, vol. 2, p. 552 (nomen nudum).—DANA, *1895*, Manual of Geology, 4th ed., fig. 1488 (nomen nudum).—HARRIS, *1895*, Acad. Nat. Sci. Philadelphia, Proc. for 1895, p. 80, pl. 9, fig. 5.—KENNEDY, *1895*, Acad. Nat. Sci. Philadelphia, Proc. for 1895, pp. 114, 116, 119, 121, 123–125, 127, 128.—VAUGHAN, *1896*, U. S. Geol. Survey, Bull. 142, p. 44.—VEATCH, *1906*, U. S. Geol. Survey, Prof. Paper 46, pl. 19, fig. 5.—VEATCH and STEPHENSON, 1911, Georgia, Geol. Survey, Bull. 26, pp. 239, 246.—DEUSSEN, *1914*, U. S. Geol. Survey, Water-Supply Paper 335, pp. 59, 60, 62, 64, pl. 5, fig. 5.—DUMBLE, *1920*, Univ. Texas, Bull. 1869, pp. 89, 92, 96, 97, 99, 100, 107.—RENICK and STENZEL, *1931*, Univ. Texas, Bull. 3101, pp. 95, 102, 103, pl. 7, figs. 21, 22.—TROWBRIDGE, *1932*, U. S. Geol. Survey, Bull. 837, pl. 42, fig. 6.—PALMER, *1937*, Bull. Am. Paleontology, vol. 7, no. 32, pp. 206–208, pl. 27, figs. 9, 10, 16.

Turritella vetusta Conrad. VAUGHAN, 1895, Am. Geologist, vol. 15, p. 213.

Mesalia obruta (Conrad).? COÖKE, *1936*, U. S. Geol. Survey, Bull. 867, p. 64.

Spire acute, abruptly tapering. Whorls numerous, straight-sided. Sutures linear, distinct on the apical whorls, but becoming less distinct with the growth of the shell, until on the later adult whorls of some specimens it is extremely difficult to distinguish between the whorls. Sculpture of apical whorl consisting of two or three obscure revolving lirae; secondary lirae appearing very early on the adolescent whorls, with no apparent constant relationship to the primary lirae; adult whorls sculptured by six or seven distinct but not prominent revolving lines, with a number of indistinct secondary lines variously placed between them. Outer lip not preserved complete on any of the specimens observed, but the growth lines indicate a simple arcuate curve with no medial sinus. Columella slightly flattened and reflected basally into a shallow spoon.

Dimensions: Not given by Harris, but the height as indicated by the original figure is 36.5 mm. Figured specimen, height, 30.5 mm; greatest diameter, 9.5 mm. This specimen is very slightly broken at the tip and the aperture is incomplete.

Type material: Holotype reported by Harris to be in the Texas State Museum, Austin, Texas. Miss Gardner[7] in her study of the collections at Austin in 1922 was unable to find this type. Figured specimen: U. S. Nat. Mus. no. 497985.

Type locality: Not given by Harris. Figured specimen: U. S. G. S. sta. 3105, Lisbon Bluff, Alabama River, Monroe County, Alabama. Claiborne group, Lisbon formation.

This species is most closely related to *Mesalia vetusta* Conrad of the "Claiborne sand" (Moodys marl) and *Mesalia georgiana* Bowles of the Barnwell sand of Georgia. It is distinguished from the first by the more acute spire and the typical lateral flattening of the whorls; in *M. vetusta* the spire is not straight-sided but convex. *M. claibornensis* does not exhibit the shouldering of the whorls anterior to the sutures or the distinctly impressed sutures of *M. vetusta*. From *M. georgiana* it is separated by the smaller size and much coarser sculpture. The rapidly tapering spire and the straight-sided whorls with shallow and indistinct sutures contrast strongly with the lower Wilcox *M. alabamiensis*, but the numerous revolving lines on the adult whorls and the bicarinate-tricarinate apical sculpture seem to indicate a relationship with the Midway and Wilcox members of the *wilcoxiana-alabamiensis* strain.

Mesalia claibornensis was first named by Timothy Conrad, and there are specimens so labelled by him in the collection of the Philadelphia Academy of Natural Science, but apparently this is one of the species whose description he forgot to publish. Heilprin (1891) and Dumble (1894) utilized the name in print, probably taking it either from the labelled specimens in the Philadelphia Academy or from Harris' Texas manuscript, but their citations were mere listings of the name without descriptions or figures, so the species dates from Harris' description in 1895. Dana's figure of the species, very slightly antedating Harris' description, was unaccompanied by any descriptive text and the figure alone is insufficient to establish the name.

[7] Gardner, Julia, oral communication, 1938.

Mesalia claibornensis is one of the most widespread species of the Gulf Eocene and one of those most characteristic of deposits of Claiborne age. Valid members of the species have been recovered from Mexico through Georgia, with a doubtful representation in South Carolina. Although fairly common in the St. Maurice formation of Louisiana, this species is not found in the collections from the Wautubbee beds of Mississippi in the National Museum. Harris has recorded *M. claibornensis* from four miles west of Enterprise, Mississippi, but Mrs. Palmer lists no Mississippi localities in her table of distribution. *M. claibornensis* is particularly abundant in the Texas deposits. It is widespread in the Cook Mountain, and is also recorded from the Reklaw member of the Mt. Selman formation. It is impossible to separate the Reklaw and Cook Mountain forms, and this Reklaw occurrence makes the apparent absence of *M. claibornensis* in the Weches member of the Mt. Selman very surprising.

Renick and Stenzel (1931,b) divided *Mesalia claibornensis* into two forms, a broad form from the base of the "Crockett" below the Moseley limestone at Stone City, on the Brazos River in Burleson County, Texas, and a narrow form ranging throughout the rest of the "Crockett." Stenzel (1936) has since separated off this lower Crockett into a new formation, the Stone City, characterized by the broad *M. claibornensis* and other species, basing his separation on depositional and lithologic as well as faunal evidence. At Moseley's Ferry (Stone City), such a separation of the variants of *M. claibornensis* can be made, but elsewhere these forms intergrade, and the varieties are not strictly confined to any particular horizon, so that a taxonomic recognition of their differences is hardly justifiable. As a rule, however, as Stenzel has pointed out, the narrow forms are more abundant in the higher horizons and the broad forms more numerous in the lower.

Harris (1895, p. 81) considered the specimens from the base of the bluff at Claiborne to be

> somewhat less broad at base, more strongly striated spirally, and with slightly more rounded volutions than the typical Texas form.

These differences do not seem to be constant and they cannot be utilized taxonomically. In the collections of the National Museum, *M. claibornensis* is present only from the upper fossiliferous horizon of the Lisbon in Alabama, the zone 7 of Cooke (1926, pp. 270–271), and is not represented from Cooke's zone 4. Zoned collections from Lisbon and Claiborne are not extensive, however, and further collecting in zone 4 might bring specimens of *M. claibornensis* to light.

The material from South Carolina is not well preserved, but the specimens exhibit characters that indicate at least a close relationship with *M. claibornensis*.

The only *Mesalia* from the McBean formation of Georgia is *M. claibornensis*, referred to as *M. vetusta* in several publications. Most of the material utilized by McCallie, Stephenson and Veatch in their faunal studies of Georgia is in the U. S. National Museum. *Mesalia vetusta* is confined to the Moodys marl of Alabama.

Distribution.—Claiborne group, McBean formation. SOUTH CAROLINA, *Aiken County:* U. S. G. S. sta. 4593?, 5 miles southeast of Aiken, one-half mile west of Dibble House. *Orangeburg County:* U. S. G. S. sta. 4580?[8] Pooser's Hill, 5.1 miles north of Orangeburg Courthouse on Columbia Road. GEORGIA, *Burke County:* U. S. G. S. sta. 3287, bluff on Brier Creek, 2½ miles above Pugeley's Bridge; U. S. G. S. sta. 3658, Shell Bluff, Boggy Gut Creek, bed 3 from bottom;[9] U. S. G. S. sta. 3659, Shell Bluff, Boggy Gut Creek at its confluence with the Savannah River, bed 8 from bottom. *Glascock County:* U. S. G. S. sta. 7710, 2 miles northeast of Gibson, on east side of Rocky Comfort Creek; U. S. G. S. sta. 7767, 1.8 miles northeast of Gibson.

Claiborne group, Lisbon formation. ALABAMA, *Choctaw County:* U. S. G. S. sta. 7882, Okatippa Creek, one-half mile above crossing and one and one-half miles north of Barrytown. *Monroe County:* U. S. G. S. sta. 3105, Lisbon Bluff, Alabama River; U. S. G. S. stas. 13431 and 14215, Lisbon Bluff, Alabama River, bed 7 of the Cooke (1926,

[8] Due to a typographical error this locality was referred to as "5580" in Cooke's report on the Geology of the Coastal Plain of South Carolina: U. S. Geol. Survey Bull. 867, p. 64, 1936.

[9] Section measured by T. W. Vaughan and give in Veatch, Otto, and Stephenson, L. W. (1911), pp. 244–245.

p. 270) section; U. S. G. S. sta. 3108, lowest bed at Claiborne Bluff, Alabama River;[10] U. S. G. S. sta. 5511, 1 mile below Lisbon Landing, Alabama River; U. S. G. S. sta. 6086, between ferry and boat landing, Claiborne, Alabama River.

Claiborne group, St. Maurice formation. LOUISIANA, *Bienville Parish:* U. S. G. S. sta. 2033, "Holston's Well," 5 miles southeast of Gibsland; U. S. G. S. sta. 2037, well at Raburn's place, sec. 29, T. 17, R. 5 W.; U. S. G. S. sta. 2400 section on Hammett's Branch, 2 miles east of Mt. Lebanon; U. S. G. S. sta. 2911, Mt. Lebanon; U. S. G. S. sta. 2917, Hammett's Branch, 2 miles northeast of Mt. Lebanon SW ¼ sec. 30, T. 18 N., R. 6 W.

Claiborne group, Mt. Selman formation, Reklaw member. TEXAS, *Bastrop County:* U. S. G. S. sta. 14212, north bank of Colorado River, across from Upton Crossroads.

Claiborne group, Cook Mountain formation. TEXAS, *Anderson County:* U. S. G. S. sta. 13265, 11.5 miles north of Grapeland on the Palestine Road. *Atascosa County:* U. S. G. S. sta. 6141, bluff on San Antonio River, 4 miles south-southeast of Floresville. *Brazos County:* U. S. G. S. sta. 4786 and 5473, Moseley's Ferry; U. S. G. S. sta. 13268, Stone City, Moseley's Ferry, lower part of greensand; U. S. G. S. sta. 14209, 9.8 miles from main corner of Bryan on highway 21, 50–300 feet upstream from the highway crossing, Little Brazos River. *Houston County:* U. S. G. S. sta. 10735, Alabama Crossing, Trinity River, 10 miles west of Porter's Springs, bed 1;[11] U. S. G. S. sta. 10736, Alabama Crossing, bed 3; U. S. G. S. sta. 10738, Alabama Crossing, bed 6; U. S. G. S. sta. 10739, Alabama Crossing, bed 7. *LaSalle County:* U. S. G. S. sta. 9167g, Encinal; U. S. G. S. sta. 13373, old Cotulla road, 2.1 miles from its intersection with the Cotulla-Tilden road, 4.5 miles southeast of Cotulla. *Lee County:* U. S. G. S. sta. 2133 (no definite locality); U. S. G. S. sta. 5272, 30-foot depth in gin well at Fedor; U. S. G. S. sta. 7565, Elm Creek; U. S. G. S. sta. 10729, Evergreen Crossing, Elm Creek, 5 miles north of Giddings. *Leon County:* U. S. G. S. sta. 14213, two-mile ford on two-mile creek, first ford above Two-mile negro church, 3–4 miles south of Middleton. *Robertson County:* U. S. G. S. sta. 2048, Montgomery's Well, one-half mile east of Wheelock; U. S. G. S. sta. 10343, Moseley's Ferry, west bank of river, 5 foot glauconitic layer; U. S. G. S. sta. 13043, Cedar Creek, southeast of Wheelock; U. S. Nat. Mus. no. 1819, Wheelock. *Sabine County:* 11103, Two miles south of Low's Creek, where north line of John Moore Survey strikes the Sabine. *Webb County:* U. S. G. S. sta. 7491, 11 miles west of Espejo Ranch on road to Chupedero Ranch, near bottom of arroyo; U. S. G. S. sta. 8771, Four miles southeast of Laredo; U. S. G. S. sta. 8817, on main county road from Laredo to San Ygnacio, 9¼ miles south of Laredo; U. S. G. S. sta. 9166, 5 miles north of Laredo in bottom of arroyo; U. S. G. S. sta. 10745, Laredo; U. S. G. S. sta. 13176, *Venericardia* and *Turritella nasuta* bed at crossing of Sendero, west of Farias Pump, Islitos Quadrangle. *Zapata County:* U. S. G. S. sta. 8871, 4½ miles north of Zapata, 300 yards south of where the Laredo-San Ygnacio-Zapata road crosses Los Molletes Creek; U. S. G. S. sta. 13192, near Presa tank at head of tributary flowing into San Bartolo from the south, Zapata Quadrangle. MEXICO, *Nuevo León:* U. S. G. S. sta. 13454, China, Carlos Cantú; U. S. G. S. sta. 13561, on road from Dr. Coss to Loma Guajardo, 2125 meters east of Dr. Coss, Zacate; U. S. G. S. sta. 13565, 50 meters northeast of U. S. G. S. sta. 13563 (2800 meters S. 55 E. of Dr. Coss), Zacate; U. S. G. S. sta. 13597, the old road just east of Realitos corrals, China, Carlos Cantú; U. S. G. S. sta. 13599, China, Carlos Cantú.

[10] This presumably means the strata below the ferruginous "Claiborne sand" (Moodys marl) taken as a whole and not necessarily the basal bed of the Cooke section.

[11] Section measured by Julia Gardner in 1924, unpublished. The section comprises 39 feet of ferruginous, glauconitic sands and shales, locally highly fossiliferous, and all referred to the Cook Mountain formation.

MESALIA VETUSTA (Conrad)
Plate 34, figure 1

Melania? vetusta CONRAD, *1833*, Fossil shells, Tertiary Formations N. America, p. 35.

Cerithium striatum LEA, *1833*, Contributions to geology, pp. 131, 132, pl. 4, fig. 122 (Not DESHAYES, *1833*.)

Proto vetusta CONRAD, *1834*, Morton's Synopsis organic remains, Appendix, p. 4.

Turritella vetusta CONRAD, *1835*, Geol. Soc. Pennsylvania Trans., vol. 1, pt. 2, p. 336.—CONRAD, *1835*, Fossil shells (republication), p. 40, pl. 15, fig. 13, Not VAUGHAN, *1895*, Am. Geologist, vol. 15, p. 213 (= *Mesalia claibornensis* Harris).

Mesalia lintea CONRAD, *1865*, Jour. Conchology, vol. 1, p. 33.—CONRAD, *1866*, Smithsonian Misc. Coll. (200), p. 11.—HARRIS, *1895*, Acad. Nat. Sci. Philadelphia, Proc. for 1895, p. 81.

Mesalia striata Lea. CONRAD, *1865*, Am. Jour. Conchology, vol. 1, p. 33.

Mesalia venusta (*Melania?*) CONRAD, *1865*, Am. Jour. Conchology, vol. 1, p. 33. (Typographical error?.)

Not *Turritella vetusta* Conrad (var.). LERCH, *1892*, Geology and agriculture of Louisiana, pt. 1, p. 29 (= *Mesalia claibornensis?*).

Pseudomelania striata (Lea). DALL, 1892, Wagner Free Inst. Sci., Trans., vol. 3, pt. 2, p. 277.

Mesalia vetusta ALDRICH, *1894, ex parte*, Alabama Geol. Survey Rept. for 1894, p. 233 (=in part *Mesalia claibornensis* Harris).—PALMER, *1937*, Bull. Am. Paleontology, vol. 7, no. 32, pp. 205–207, pl. 27, figs. 7, 8, 13–15. Not ALDRICH *1886*, Alabama Geol. Survey, Bull. 1, p. 46 (= *Mesalia claibornensis* Harris).—HARRIS, *1895*, Bull. Am. Paleontology, vol. 1, no. 1, pp. 43, 48, 50, pl. 1, fig. 6.—Not MCCALLIE, *1908*, Georgia Geol. Survey, Bull. 15, pp. 337, 338, 340–342, 345–348 (p. 337 = *Mesalia claibornensis* Harris; pp. 338, 340–342, 346, 347 = *Mesalia georgiana* Bowles, pp. 345, 348 = *Mesalia* sp.—Not VEATCH and STEPHENSON, 1911, Georgia Geol. Survey, Bull. 26, pp. 246, 256, 258, 259, 276, 278, 282, 286, 289, 292, 295 (pp. 246, 256, 258, 259, 276, 282, 295 = *Mesalia claibornensis* Harris: pp. 286, 289, 292 = *Mesalia georgiana* Bowles).—Not STEPHENSON and VEATCH, *1915*, U. S. Geol. Survey, Water-Supply Paper 341, p. 80 (= *Mesalia georgiana* Bowles).—Not BRANTLY, *1916*, Georgia, Geol. Survey, Bull. 21, p. 19 (= *Mesalia claibornensis* Harris?).

Spire high, abruptly tapering; whorls numerous, robust, much inflated. Sutures linear, distinct and rather deeply impressed, the posterior portion of each whorl encroaching slightly on the preceding whorl and forming a definite shoulder; this character variable, some of the larger specimens exhibiting a marked shouldering with some of the others more nearly approaching the straight-sided whorls of *Mesalia claibornensis*. First two or three whorls smooth, very fine revolving lines appearing on the third or fourth, incremental striae appearing simultaneously with the appearance of this spiral sculpture. Incrementals extremely prominent in this species, forming the "longitudinal wrinkles" spoken of both by Conrad and Lea in their descriptions; these prominent, gently arcuate growth lines, the dominant sculpture for the first seven or eight volutions on some of the specimens, their relative prominence decreasing with the growth of the shell and the strengthening of the spiral sculpture. Adult whorls marked by numerous fine revolving lines, with even finer lines variously placed between them, two or three between each of the primary lines on the body whorls of some of the largest specimens. Outer lip very thin and fragile and rarely preserved entire. Parietal callus well developed. Columella flattened and reflected basally in a shallow but distinct spoon.

Dimensions: "Length, 1¾ inches" (Conrad, 1833). Lectotype of *M. vetusta* (as given by Palmer): "Height, 31 mm, greatest diameter, 11 mm" (Palmer, 1937). Lectotype of *Cerithium striatum* Lea: "Height, 31 mm, greatest diameter, 11 mm" (Palmer, 1937). Figured specimen: Height, 30.5 mm; greatest diameter, 10 mm.

Type material: Lectotype and several paratypes in the Philadelphia Academy of Science. Lectotype of *Cerithium striatum* Lea, Acad. Nat. Sci. Philadelphia, no. 5620; paratypes of *Cerithium striatum* Lea, A. N. S. nos. 5671–5683. Figured specimen (topotype), U. S. Nat. Mus. no. 494979.

Type locality: Claiborne Landing, Alabama River, Monroe County, Alabama. Figured specimen (topotype): U. S. G. S. sta., 2867. Jackson group, Moodys marl.

This species differs from *Mesalia claibornensis* of the Claiborne in the finer revolving sculpture, the more prominent incremental striae, the more gradual tapering of the spire, and the shouldering of the whorls. The closest analogue is *Mesalia georgiana* of the Barnwell sand of Georgia, but this more eastern species, has a more rapidly tapering spire and extremely fine sculpture, most of it invisible to the naked eye. As a rule *M. georgiana* is larger than *M. vetusta*.

Mesalia vetusta is known only from the Moodys marl of Alabama. The numerous references to it in other deposits are, as pointed out in the synonymy, misidentifications. Conrad's misspelling of the name in 1865 and 1866 has been repeated widely in the literature.

Mrs. Palmer (1937, p. 206) says of this form

> *Mesalia vetusta* is the most abundant species in the Harris collection of the Gosport sand. There are hundreds of specimens. The shell must have been fragile for one finds a large number of specimens which have been injured before maturity. The growth of the shell was continued but the line of the spire became curved or one part of the shell set obliquely to the other.

Distribution.—Jackson group, Moodys marl. ALABAMA, *Monroe County:* U. S. G. S. stas. 263, 2391, 2666, 2867, U. S. N. M. nos. 1527, 1531, 5145, 11384, 11385, 90994, and 129675. Claiborne Landing, just below highway bridge, Alabama River. *Conecuh County:* U. S. G. S. sta. 6737, east side of Sepulga River, on land of J. G. Robinson, sec. 13(?), T. 4 N., R. 13 E. *Clarke County:* U. S. G. S. sta. 7880, Rocky Creek, 10 miles east of Salitpa.

MESALIA GEORGIANA Bowles, n. sp.
Plate 34, figures 12, 13

Mesalia vetusta Conrad. MCCALLIE, *1908, ex parte*, Georgia Geol. Survey, Bull. 15, pp. 338, 340, 342, 346, 347. (Not p. 337 = *M. claibornensis* Harris, nor pp. 345, 348 = *M.* sp.?.) —VEATCH, and STEPHENSON, *1911, ex parte*, Georgia Geol. Survey, Bull. 26, pp. 286, 289, 292. (Not pp. 246, 256, 259, 276, 282, 295 = *M. claibornensis* Harris.)—STEPHENSON and VEATCH, *1915*, U. S. Geol. Survey, Water-Supply Paper 341, p. 80.

Spire high, robust, abruptly tapering. Sutures linear, distinct, not deeply impressed; much more comparable to the sutures of *M. claibornensis* than to those of *M. vetusta*. Apical whorls not well preserved, but apparently smooth or sculptured only by extremely fine lines; adolescent whorls marked by numerous very fine subequal revolving lines, which increase in strength but slightly with the growth of the shell; 23 of these faint revolving subequal lirae, hardly discernible to the naked eye on the adult. Incrementals distinct, but not prominent, gently arcuate, first appearing at about the same time as the spiral sculpture. Outer lip very thin and fragile, not preserved entire on any of the specimens. Columella slightly reflected basally in a shallow but distinct spoon.

Dimensions: Holotype, height, 33.5 mm; greatest diameter, 13.5 mm. Paratype, height, 39.5 mm; greatest diameter, 15.5 mm. The holotype is broken at the tip and the edge of the outer lip, and the paratype does not have the aperture preserved.

Type material: Holotype, U. S. N. M. no. 498008; paratype, U. S. N. M. no. 498007.

Type locality: U. S. Geol. Survey sta. 7428, 7½ miles southeast of Louisville, Jefferson County, Georgia (holotype). U. S. G. S. sta. 3938, 9 miles southeast of Louisville, Jefferson County, Georgia (paratype).

This species most closely resembles *Mesalia claibornensis* Harris of the Claiborne. As a rule the specimens are larger, however, and the sculpture pattern is quite distinct. The numerous very fine subequal revolving lines distinguish this form from any other in the Eocene of the Gulf Province. The outline of the shell, the fine sculpture, and the lack of shouldering of the whorls separate *M. georgiana* from the Jackson *M. vetusta*.

This species is probably referable to the *wilcoxiana-alabamiensis-claibornensis* strain and, with *vetusta* marks the culmination of that virile race.

MESALIA HARDEMANENSIS (Gabb)
Plate 34, figure 9

Turritella hardemanensis GABB, *1860*, Acad. Nat. Sci. Philadelphia, Jour., 2d ser., vol. 4, p. 392 pl. 68, fig. 15.—Not WHITFIELD, *1891*, U. S. Geol. Survey, Mon. 18, p. 145. (=Cretaceous species, probably not conspecific with *M. hardemanensis*.)

Mesalia? sp. HARRIS, *1896*, Bull. Am. Paleontology, vol. 1, no. 4, p. 114, pl. 12, fig. 3.

Mesalia pumila var. *hardemanensis* HARRIS, *1896*, Bull. Am. Paleontology, vol. 1, no. 4, pp. 112, 113, pl. 11, figs. 18, 19.—DEUSSEN, *1914*, U. S. Geol. Survey, Water-Supply Paper 335, pp. 32, 36.—GARDNER, *1935*, Univ. Texas, Bull. 3301, p. 297.

Mesalia pumila (Gabb). LOWE, *1933*, Mississippi Geol. Survey, Bull. 25, p. 10.

Mesalia sp. LOWE, *1933*, Mississippi Geol. Survey, Bull. 25, p. 9.

Spire high?, rather gradually tapering. Whorls rounded, sharply constricted at the distinct, deeply impressed sutures. Sculpture consisting of a very prominent medial carina on the early whorls, with an accessory cord posterior to it and another anterior to it arising on the adolescent whorls and gradually becoming more prominent on the later; the median carina on the adult whorls more or less flat-topped, with slightly rounded margins, not sharp as in *Turritella*

postmortoni Harris and *T. praecincta* Conrad; finer lines occasionally appearing on the adult whorls, variously placed in respect to the median carina and the anterior and posterior accessory cords. Incrementals indistinct, simple, gently arcuate, not reflexed. Aperture unknown.

Dimensions: Holotype, "Length .6 in., width of body whorl .27 in., length of mouth .2 in." (Gabb, 1860). Figured specimen (U. S. N. M. 497986), height, 9 mm; greatest diameter, 6. 5 mm.

Type material: Holotype apparently lost. The specimens described by Gabb could not be located with the other Gabb material in the Academy of Natural Sciences at Philadelphia. Some of the material collected by Doctor Safford in Tennessee and described by Gabb is at Vanderbilt University, but the type of this species is not there.

Type locality: "Hardeman Co., Tennessee" (Gabb, 1860). Figured specimen (U. S. N. M. 497986), U. S. G. S. sta. 6495, 1.5 miles east of Middleton and 200 feet west of milepost 481, Hardeman County, Tennessee. Midway group, Porters Creek clay.

The only specimens of this species from Tennessee in the collections of the National Museum are two fragments, one with two of the adult whorls preserved and the other showing several of the adolescent whorls. The whorls on these Tennessee forms, though incomplete, are very well preseved, and the characteristic carination readily identifies this material with the species as described by Gabb. This is the only medially carinate *Mesalia* found in the Eastern Gulf Embayment, and it cannot be confused with any other species. *Mesalia sayi* from the lower Eocene of Mexico exhibits the medial carination only on the apical whorls, and the revolving cord is relatively not so wide, nor does it have the rounded edges and flat top that distinguish the carina of *M. hardemanensis*.

The material from Tippah County, Mississippi, referred by Lowe (1933, p. 10) to *Mesalia pumila* (Gabb), though poorly preserved, contains a few molds representing a medially carinate *Mesalia*, somewhat larger than the Tennessee material, but on the whole similar.

In a collection from the Black Mingo formation of South Carolina there are some poorly preserved medially carinate Mesalias that are probably referable to this species. The shells are somewhat larger than those from Tennessee, but the sculpture of the adult whorls is similar. Unfortunately none of the apical whorls are well preserved and the sculpture is indistinct.

The only representative of the genus *Mesalia* in the deposits of the Pacific coast, *M. martinezensis* (Gabb) (1869) from the Paleocene of California, is a medially carinate form somewhat resembling *M. hardemanensis*. Both these species resemble, at least superficially, *Arcotia indica* Stoliczka of the Indian Cretaceous. Stewart has suggested that were it not for the variability of the form of these species, the name *Arcotia* might be utilized for the medially carinate species.

Distribution.—Midway group, Porters Creek formation. TENNESSEE, *Hardeman County:* U. S. G. S. sta. 6495, cut on Southern Railway, 1.5 miles east of Middleton, and 200 feet east of milepost 481. MISSISSIPPI, *Tippah County:* U. S. G. S. sta. 6497, bluff on south side of Owl Creek, 2.75 miles northeast of Ripley, about ¼ mile east of the Ripley-Troy road.

MESALIA SAYI Bowles, n. sp.
Plate 33, figure 6

Spire abruptly tapering. Sutures distinct, deeply impressed and slightly overhung on the adolescent whorls where the revolving cords just posterior to the suture become very pronounced. Apical whorls marked only by a strong revolving medial carination. A secondary revolving cord appears posterior to this primary carination on the second or third whorl, more secondary cords added posterior to the carination on the few succeeding whorls, until on the adult whorls there are three or four, gradually increasing in strength with the growth of the shell. Incrementals deeply arcuate, but simple and not reflected. Aperture unknown.

Dimensions: Holotype, height, 18.0 mm; greatest diameter, 12.0 mm. Paratype, height, 8.0 mm; greatest diameter, 4.5 mm. Both the holotype and paratype are incomplete specimens.

Type material: Holotype, U. S. N. M. no. 494798; paratype, U. S. N. M. no. 494799.

Type locality: U. S. G. S. sta. 13450, on road from Rancho Durazno to Rancho Las Flores, 520 meters southeast of crossing of east-west brecha, Nuevo León, Mexico. Lower Wilcox group.

The closest analogue of this species is *M. hardemanensis* (Gabb) of the Porters Creek clay of Mississippi and Tennessee. The northern species, however, bears only a superficial resemblance to the Mexican form, but it is the only species in the northern Gulf Embayment that even approximates the sharp medial carination of *M. sayi*. *M. hardemanensis* has more rounded whorls than *M. sayi*, and it never shows the numerous secondary revolving cords that are so characteristic of the adult whorls of the Mexican form.

Distribution.—Lower Eocene. MEXICO, *Nuevo León:* U. S. G. S. sta. 13450, on road from Rancho Durazno to Rancho Las Flores, 520 meters southeast of crossing of east-west brecha; U. S. G. S. sta. 13462, downstream section of tilted shales on the Rio San Juan, a few feet west of and stratigraphically below 13485; U. S. G. S. sta. 13485, downstream section of tilted shales on Rio San Juan, highest of three outcrops from which collections were taken but below the series of evenly stratified and tilted shales; U. S. G. S. sta. 13486, downstream section of tilted shales on Rio San Juan, the most western and stratigraphically the lowest outcrop in the section; U. S. G. S. sta. 13438, upstream section on Rio San Juan upthrow side of fault; U. S. G. S. sta. 13489, Rio San Juan, 3 miles airline east of La Alameda Ranch; U. S. G. S. sta. 13499, 3 miles west of Altamira Ranch, Coyote Concession; U. S. G. S. sta. 13491, same as sta. 13490; U. S. G. S. sta. 13493, 3 miles northeast of La Alameda Ranch, Coyote Concession; U. S. G. S. sta. 13349, in main bed of Rio San Juan, south of Rancho Ermita (de Abajo), 41 feet below the top of the flag sandstone series.

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EQUIVALENCE OF THE GOSPORT SAND TO THE MOODYS MARL

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ABSTRACT—The Gosport sand of Alabama, heretofore classified as the topmost formation of the Claiborne group (Eocene), and the only known formation of "upper Claiborne" age, proves to be nearly equivalent to the Moodys marl of Mississippi, the basal formation of the Jackson group. It is recommended that the name Gosport be replaced by Moodys, and that the Claiborne group be restricted to the formations heretofore classified as lower Claiborne.

AS A RESULT of stratigraphic studies begun in 1912 and carried on intermittently through many years, it has been discovered that the Moodys marl of Mississippi bears a strong resemblance to the Gosport sand of Alabama, and that the stratigraphic relations are such as to make the conclusion inevitable that the two represent a single formation. This conclusion is the more surprising because the Moodys is the type formation of the Jackson group and the Gosport is the original "Claiborne sands" from which Conrad and Lea obtained most of their Claiborne fossils. Several years ago the writer communicated this conclusion to friends, who were so incredulous that he refrained from publishing it without paleontologic proof. Press of other work prevented him from making detailed comparisons of the Claiborne and Jackson faunas himself, but recently Dr. Julia Gardner, whose lists appear elsewhere in this journal, undertook the task.

In November 1938 Doctor Gardner and the writer examined the Gosport sand at Claiborne, Gosport, Stave Creek, Baker Hill, and Willow Branch, in Alabama; and Garlands Creek, Jackson, and a place formerly known as Sims in Yazoo County about 2 miles south of Eden, in Mississippi. Through the courtesy of Dr. Walter B. Jones, State Geologist, they were accompanied while in Alabama by Miss Winnie McGlamery and Mr. Edgar Bowles of the Geological Survey of Alabama, whose intimate knowledge of the region was of great assistance.

HISTORY OF THE NAMES

Fossil shells from the bluff at Claiborne, Alabama, were first called to the attention of scientists by Timothy Conrad (1832–35) and Isaac Lea (1833). Later (1847), Conrad referred to the most conspicuous bed of shells there as the "Claiborne sands," which he placed in the "lower or older Eocene." In 1855 he divided the "older Eocene" into the Jackson group, above, and the Claiborne group, below, the Claiborne group containing the "Claiborne sands" of 1847 as its topmost bed (Conrad, 1856). Smith (1907) renamed this bed the Gosport greensand, the name being taken from a landing on the Alabama River in Clarke County four miles below Claiborne. He explained that "its importance in Alabama, from the historical point of view and because of the great number and variety and beautiful state of preservation of its fossils, is such as to compel mention and a distinct name."

Fossil shells from Jackson, Mississippi, were figured by Wailes in 1854 and described the following year by Conrad (1856), who then named the Jackson group. More fossils from the same zone, which he attributed to Enterprise, Mississippi, though they really were collected on Garlands Creek, Clarke County, Mississippi, 3½ miles north-northeast of Shubuta (Aldrich, 1885), were described by Conrad (1865) ten years later.

The undefined name "Moody's Branch" was used in tables for deposits of Jackson age in Mississippi by Otto Meyer (1885) and by Harris (1894). The beds were first

defined as a formation in the Jackson group by Lowe (1915), who used the name "Moody's Branch green marls," citing as type locality a small tributary within the city limits of Jackson. The name was later modified to "Moody's calcareous marl member of the Jackson formation" by Cooke (1918), who treated it as a member because there was no obvious boundary between it and the overlying Yazoo clay and because the Jackson was then classified by the Geological Survey as a formation rather than a group as at present. He omitted the word Branch for brevity. The word calcareous was inserted because Survey practice at that time required the use of a restrictive adjective with the noun marl.

STRATIGRAPHIC RELATIONS

There can be no question as to the location of the base of the Gosport sand at Claiborne. The base is marked by the abrupt change to the greenish glauconitic marl of the underlying Lisbon formation, which contains large *Ostrea sellaeformis*. The relations are those of unconformity, for beds of "lower Claiborne" age that overlie the *Ostrea sellaeformis* zone elsewhere are missing at Claiborne.

The top of the Gosport at Claiborne is much less definite. The formation merges upward into ledges of calcareous sandstone containing *Periarchus lyelli* (the "*Scutella*" bed), which appear to be perfectly conformable with the overlying Ocala limestone, of Jackson age, here partly transitional to the Yazoo clay.

The base of the formation was not seen at Gosport nor at Baker Hill, but on Stave Creek it rests unconformably on the Lisbon formation, which here consists of greenish clay perforated by burrows filled with Gosport sand. The top of the Gosport on Stave Creek, Willow Branch, and at Baker Hill merges through the *Periarchus lyelli* zone into the Yazoo clay.

At Moodys Branch, Garlands Creek, and at all other places in Mississippi where the writer has seen the lower part of the Jackson, the Moodys consists of a sandy shell marl resting unconformably on black clay or dark-gray sand, referred to the Yegua formation, which is perforated by connected vertical and horizontal burrows filled with sand from the Moodys marl. The shell bed merges upward through ledges containing *Periarchus lyelli* (the "*Scutella*" bed) into the Yazoo clay. The Moodys marl of Mississippi bears a striking resemblance, both in lithologic characteristics and in stratigraphic relations, to the Gosport sand of Alabama. As both merge upward with no discernible interruption into equivalent beds, and as both are separated from beds below by a stratigraphic break, the evidence is strong that the Gosport and the Moodys are at least partly contemporaneous.

COMPARISON OF THE FAUNAS

Opposed to this stratigraphic evidence is the tradition of 85 years based on rather obvious differences between the faunas. These differences appear to be due partly to ecologic differences (the Gosport is a very shallow water fauna including a good many littoral species) and partly to differences between the ages of the basal beds at different places. The Gosport and the Moodys represent the deposits of a transgressing sea that first invaded the Claiborne area, bringing with it some representatives of the Lisbon fauna as well as several large, conspicuous species (*Venericardia alticostata*, *Crassatellites alta*, etc.) that have not been found in Mississippi. Later the transgression continued westward into Mississippi carrying a transition fauna, which, in turn, was succeeded by the typical Jackson fauna at the base of the formation at Moodys Branch. A good many of the species of this later fauna have been recognized in the upper part of the formation in Alabama.

EQUIVALENTS

The Gosport sand has never been recognized as such outside of Alabama. For many years the Yegua formation, extending from Texas to eastern Mississippi, was supposed to be equivalent to the Gosport sand because it lies between the Jackson group and deposits of known "lower Claiborne" age, and because a few of the fossil leaves in it have been identified in the Gosport. The type sections of the Yegua, however, contain a characteristic "lower Claiborne" fauna (Gardner, 1927).

The Barnwell sand of Georgia and South

Carolina was placed in the Claiborne group by Veatch and Stephenson (1911) because Vaughan had identified several characteristic Gosport species in it, but Cooke and Shearer (1918) showed that its stratigraphic position precludes it from being any age but Jackson. If the Gosport is basal Jackson instead of "upper Claiborne," as originally classified, Vaughan's correlation of the Barnwell with it is corroborated.

The Eocene deposits at White Bluff, Arkansas, which also contain many Gosport species and which were originally referred to the Claiborne group, proved later to be of Jackson age (Harris, 1894). If the Gosport is Jackson, this early correlation also is verified.

RECOMMENDATIONS

Both the Gosport and the Moodys are sandy shell marls at most of the known outcrops. They resemble each other so closely that the use of more than one name seems superfluous. Which name should be retained? The Moodys was first named in 1885 although it was not defined until 1915. The Gosport was named and defined in 1907. The Moodys is the typical part of the Jackson group. The Gosport forms only a small part of the typical Claiborne. The Gosport has been recognized only in Alabama, but the "lower Claiborne" is well developed in every coastal State from South Carolina to Mexico. Moreover, the Gosport is separated from the "lower Claiborne" by an unconformity. The writer therefore has recommended that the Claiborne group be restricted to deposits of "lower Claiborne" age, that the name Gosport sand be abandoned, and that the application of the name Moodys marl be extended into Alabama to include the Gosport.

The Moodys marl has been traced practically unchanged from the Delta of Mississippi eastward far into Alabama, and the same zone can be recognized by its fossils in Arkansas, Georgia, and South Carolina. Though its upper limit is not a sharp line, its transition to the Yazoo clay or the Ocala limestone takes place within a few feet. The Moodys is easily mappable. It therefore seems desirable to recognize the Moodys as an independent formation in the Jackson group, as Lowe originally defined it.

Elimination of the Gosport from the Claiborne group has the advantage of making that group a more compact and distinctive unit. The fauna of the Claiborne group, by that elimination restricted to the "lower Claiborne" fauna, stands out in much sharper contrast to that of the Jackson group, which likewise gains in distinctiveness. Recognition of the Jackson as a group within the Eocene coordinate in rank with the Claiborne group is more than ever justified now that the Gosport proves to be Moodys.

An unfortunate but unavoidable result of the transfer of the Gosport to the Jackson group is that many species that are traditionally credited to the Claiborne group no longer belong there. Some confusion inevitably will follow, but it is hoped that systematic studies now in progress by other workers will soon restore order.

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RECENT COLLECTIONS OF UPPER EOCENE MOLLUSCA FROM ALABAMA AND MISSISSIPPI

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THE FOLLOWING list enumerates the more significant identified species of Mollusca collected by C. Wythe Cooke and the writer in November 1938 from several outcrops of the formation commonly called the Gosport sand in Alabama, and from the Moodys marl at Garland Creek, Clarke County, and Sims Siding, Yazoo County, in Mississippi. The occurrence of these species at Jackson, Miss., is checked against collections in the U. S. National Museum from Moodys Branch. The collections are deposited in the U. S. National Museum. The Gosport, which includes Conrad's original "Claiborne sands" at the base, and the Moodys, which is the oldest formation of the Jackson group, represent a single formation, for which the name Moodys marl has priority.

A time sequence including three faunas is indicated by the lists. The oldest, which contains *Venericardia alticostata* in abundance, is included in the "Claiborne sand" in the outcrops at Claiborne and Gosport Bluff on the Alabama River, in the section along Little Stave Creek in Clarke County, and at the first bend on the Tombigbee River a mile or less above St. Stephens Bluff at an outcrop cited in the older publications as Gopher Hill but later known as Bakers Hill. The *Venericardia alticostata* zone has not been recognized west of the Tombigbee.

Succeeding the *alticostata* fauna is a transition assemblage, which includes *Mesalia vetusta*, abundant at Claiborne and at Gosport Bluff but unknown at Jackson, Miss., and such species as *"Leda" multilineata*, *Eburneopecten scintillatus*, *Myrtaea curta* and *Turritella arenicola*, which are characteristic of the zone at Moodys Branch and Garlands Creek but unknown at Claiborne. The transition fauna has been recovered from Willow Branch in Choctaw County, Ala., from Sims Siding, 10 miles north of Yazoo City, Miss., and it is probably represented in the glauconitic sand three quarters of a mile below Robinsons Ferry on the Sabine River, Sabine County, Texas. This is the *Nonionella cockfieldensis* zone of the micropaleontologists.

From the latest of the three faunas, that at Moodys Branch and Garlands Creek, only those species are cited which are common to the earlier horizons. It is possible that the outcrop on Garlands Creek, in which *Turritella arenicola* occurs in great abundance, is slightly older than those on Moodys Branch and Town Creek at Jackson, Miss., in which *T. arenicola* is absent or exceedingly rare.

The letters preceding the name of the species indicate its occurrence as follows:

M. Outcrops of Moodys marl in the vicinity of Jackson, Miss.

U. Garland Creek, 4 miles northeast of Shubuta, Clarke County, Miss.

Y. Sims Siding, about 1½ miles south of Eden, Yazoo County, Miss.

W. Willow Branch near crossing of old road from Fail to Silas, Choctaw County, Ala.

B.[1] Bakers Hill (Gopher Hill), about one mile above St. Stephens Bluff on the Tombigbee River, Washington County, Ala. Upper bed.

B.[2] Bakers Hill (Gopher Hill). Lower bed.

S. Little Stave Creek, about 4½ miles north of Jackson, Ala.

C. Road cut at highway bridge at Claiborne, Ala. Directly above *Ostrea sellaeformis* bed.

G. Gosport Bluff, Alabama River, in Clarke County, Ala., about 4 miles below Claiborne.

UPPER EOCENE MOLLUSCA

		Y		B[1]	B[2]	S	C	G	*Nucula magnifica* Conrad
M	U		W						*Nucula spheniopsis* Conrad
M	U	Y	W						"*Leda*" *multilineata* Conrad
						S		G	*Calorhadia opulenta* (Conrad)
					B[2]			G	*Calorhadia semen* (Lea)
				B[1]	B[2]			G	*Calorhadia bella* (Conrad)
						S		G	*Calorhadia media* (Lea)
M	U	Y							*Calorhadia mater* (Meyer)
				B[1]					*Calorhadia pistorupis* (Harris)
							C	G	*Lembulus coelatus* (Conrad)
					B[2]		C	G	*Limopsis aviculoides* Conrad
					B[2]	S	C	G	*Halonanus ellipsis* (Lea)
						S		G	*Halonanus decisus* (Lea)
								G	*Trinacria cunea* (Conrad)
					B[2]				*Calloarca aldrichi* (Dall)
							C	G	*Barbatia rhomboidella* (Lea)
					B[2]	S	C	G	*Glycymeris trigonella* (Conrad)
	U	Y		B[1]		S	C	G	*Glycymeris staminea* (Conrad)
					B[2]				*Glycymeris idonea* (Conrad)
			W						*Verticordia eocensis* Langdon
					B[2]	S	C	G	*Crenella isocardioides* (Lea)
				B[1]	B[2]	S			*Chlamys deshayesii* (Lea)
M	U	Y	W						*Eburneopecten scintillatus* Conrad
						S	C	G	*Plicatula filamentosa* Conrad
M	U	Y		B[1]		S		G	*Pteria limula* (Conrad)
								G	*Ostrea alabamiensis* Lea
M	U					S			*Ostrea trigonalis* Conrad
				B[1]	B[2]	S			*Lirodiscus tellinoides* Conrad
				B[1]	B[2]	S	C	G	*Crassatellites protextus* (Conrad)
						S			*Crassatellites alta* Conrad
M	U		W	B[1]	B[2]	S	C	G	*Crassinella minor* (Lea)
						S		G	*Micromeris parva* (Lea)
		Y				S		G	*Micromeris parva subparva* Meyer
					B[2]			G	*Micromeris minutissima* (Lea)
				B[1]		S		G	"*Pleuromeris*" *aldrichi* Harris
				B[1]		S		G	*Venericardia* (*Venericor*) race of *V. planicosta* Lamarck
				B[1]	B[2]	S		G	*Venericardia* (*Glyptoactis*) *alticostata* Conrad
		Y		B[1]		S	C	G	*Venericardia rotunda* Lea
			W	B[1]	B[2]	S	C	G	*Venericardia* (*Pleuromeris*) *parva* Lea
					B[2]	S	C	G	*Lucina* (*Cavilinga*) *pomilia* Conrad
					B[2]	S			*Lucina* (*Cavilinga*) *smithi* Meyer
				B[1]	B[2]	S	C	G	*Lucina* (*Cavilinga*) *impressa* Lea
				B[1]	B[2]	S	C	G	*Lucina* (*Cavilucina*) *alveata* Conrad
						S	C	G	*Lucina* (*Recurvella*) *dolabra* Conrad
					B[2]	S		G	*Miltha* (*Eomiltha*) *pandata* (Conrad)
					B[2]	S			*Corbis undata* Conrad
								G	*Corbis claibornensis* Dall
						S			*Hindsiella donacia* Dall
M	U	Y	W						*Myrtaea curta* Conrad
				B[1]	B[2]	S		G	*Diplodonta ungulina* (Conrad)
					B[2]		C		*Diplodonta nana* (Lea)
						S			*Diplodonta inflata* (Lea)
				B[1]		S			*Sphaerella* sp.

UPPER EOCENE MOLLUSCA—*Continued*

M	U	Y	W		B^2	S			*Alveinus minutus* Conrad
				B^1					*Tellina cynoglossula* Harris
M	U					S			*Tellina linifera* Conrad
					B^2		C	G	*Tellina* (*Moerella*) *leana* Dall
						S			*Macoma danai* Harris
					B^2	S	C	G	*Egerella subtrigonia* (Lea)
				B^1		S	C		*Abra nitens* (Lea)
				B^1					*Gari eborea* Conrad
					B^2				*Mactropsis aequorea* Conrad
						S		G	*Spisula parilis* (Conrad)
M	U	Y	W						*Spisula jacksonensis* Cooke
				B^1		S		G	*Callocardia aequorea* (Conrad)
			W	B^1	B^2	S	C	G	*Callocardia perovata* (Conrad)
								G	*Callocardia poulsoni* (Conrad)
M	U	Y							*Callocardia securiformis* (Conrad)
						S			*Callocardia aldrichi* Harris
								G	*Cytheriopsis hydana* Conrad
				B^1		S	C	G	*Corbula murchisoni* Lea
					B^2		C	G	*Corbula gibbosa* Lea
M	U	Y	W						*Corbula wailesiana* Harris
M	U	Y							*Corbula* (*Caryocorbula*) *densata* Conrad
				B^1	B^2	S	C	G	*Corbula* (*Caryocorbula*) *alabamiensis* Lea
				B^1	B^2	S	C	G	*Corbula* (*Caryocorbula*) *compressa* Lea
					B^2				*Gastrochaena larva* Conrad
M						S			*Panope oblongata* Conrad
							C		*Teredo simplex* Lea
				B^1	B^2	S	C	G	*Dentalium thalloide* Conrad
								G	*Fissurella tenebrosa* Conrad
						S		G	*Solariella stalagmium* (Conrad)
				B^1			C	G	*Solariella tricostata* (Conrad)
						S	C	G	*Norrisia* (*Norrisella*) *nitens* (Lea)
						S		G	*Circulus exacuus* (Conrad)
								G	*Architectonica amoena* Conrad
				B^1					*Architectonica fungina* Conrad
				B^1					*Architectonica* (*Granosolarium*) *cossmanni* Dall
				B^1	B^2	S			*Architectonica* (*Granosolarium*) *elaborata* (Conrad)
M	U			B^1				G	*Architectonica* (*Stellaxis*) *alveata* Conrad
								G	*Bayania secale* (Lea)
						S	C	G	*Tenagodes vitis* (Conrad)
								G	*Turritella apita* DeGregorio
	U	Y	W						*Turritella arenicola* Conrad
				B^1	B^2	S	C	G	*Turritella carinata* Lea
	U		W?						*Turritella perdita* Conrad
						S		G	*Turritella obruta* Conrad
		Y	W	B^1	B^2	S	C	G	*Mesalia vetusta* (Conrad)
								G	*Gegania antiquata* (Conrad)
								G	*Cerithiella preconica* Palmer
								G	*Seila constricta* (Lea)
						S		G	*Triphora similis* (Meyer)
						S			*Cirsotrema* (*Coroniscala*) *nassula* (Conrad)
							C		*Acirsa* (*Hemiacirsa*) *gracilior* (Meyer)
					B^2				*Cirsocheilus claibornensis* Dall
								G	*Pasitheola guttula* (Lea)
								G	*Odostomia melanella* (Lea)
								G	*Syrnola meyeri* Cossmann
M	U	Y							*Amalthea americana* Conrad
M				B^1	B^2	S	C	G	*Hipponix pygmaeus* (Lea)
				B^1	B^2	S	C	G	*Crepidula lirata* Conrad
M	U			B^1				G	*Calyptraea aperta* (Solander)
		Y		B^1	B^2	S	C	G	*Natica* (*Naticarius*) *semilunata* Lea
					B^2	S	C	G	*Neverita limula* (Conrad)
M				B^1?					*Polynices eminula* Conrad
				B^1					*Sinum declive* (Conrad)
								G	*Sinum bilix* (Conrad)
				B^1	B^2	S		G	*Sinum beatricae* Palmer

UPPER EOCENE MOLLUSCA—*Continued*

M	U	Y	W	B^1	B^2	S	C	G	*Calyptraphorus velatus* Conrad
						S	C	G	*Sconsia nupera* (Conrad)
					B^2	S		G	*Ficopsis penita* (Conrad)
				B^1					*Mitrella* (*Columbellopsis*) *elevata* (Lea)
						S			*Mitrella* (*Columbellopsis*) *parva* (Lea)
								G	*Terebrifusus amoenus* Conrad
					B^2	S	C	G	*Buccitriton sagenus* Conrad
								G	*Laevibuccinum prorsum* Conrad
				B^1	B^2	S		G	*Pseudoliva vetusta* Conrad
					B^2	S		G	*Ancillopsis subglobosa* Conrad
					B^2	S			*Cornulina armigera* Conrad
					B^2	S		G	*Lacinia alveata* Conrad
								G	*Mazzalina inaurata* (Conrad)
					B^2			G	"*Fusus*" *bellus* Conrad
						S		G	"*Fusus*" *bellus leai* Palmer
						S		G	"*Fusus*" *delabechii* Lea
								G	"*Fusus*" *limulus* Conrad
						S		G	*Levifusus mortoni* (Lea)
					B^2				*Levifusus irrasus* (Conrad)
								G	*Ancilla scamba* (Conrad)
				B^1	B^2	S	C	G	*Ancilla* (*Olivula*) *staminea* (Conrad)
								G	*Monoptygma lymneoides* Conrad
				B^1	B^2	S	C	G	*Agaronia alabamiensis* (Lea)
				B^1	B^2		C	G	*Agaronia bombylis* (Conrad)
								G	*Marginella columba* Lea
							C		*Marginella silibra* Palmer
						S		G	*Persicula larvata* (Conrad)
M					B^2		C	G	*Persicula semen* (Lea)
								G	*Fusimitra perexilis* (Conrad)
				B^1	B^2		C	G	*Conomitra fusoides* (Lea)
				B^1		S		G	*Volutospina petrosa* (Conrad)
				B^1	B^2	S		G	*Volutospina sayana* (Conrad)
					B^2	S		G	*Volutospina sayana mica* (DeGregorio)
				B^1	B^2	S	C	G	*Caricella pyruloides* Conrad
								G	*Caricella praetenuis* Conrad
								G	*Caricella doliata* Conrad
						S		G	*Lapparia pactilis* Conrad
					B^2			G	*Trigonostoma gemmatum* (Conrad)
								G	*Cancellaria* (*Sveltella*) *parva* Lea
						S			*Cancellaria* (*Sveltella*) *turritissima* (Meyer)
					B^2		C		*Pleurofusia longirostropsis* (DeGregorio)
				B^1					*Coronia childreni* (Lea)
				B^1					*Coronia childreni acutirostra* (Conrad)
								G	*Eopleurotoma nupera* (Conrad)
						S		G?	*Eopleurotoma nupera nuppygis* Harris
					B^2	S	C		*Eopleurotoma hoeninghausii* (Lea)
				B^1		S			*Eopleurotoma sayi* (Lea)
								G	*Eopleurotoma gemmata* (Conrad)
								G	*Surculoma subaequalis* (Conrad)
M						S			*Eucheilodon creno-carinatus* Heilprin
						S		G	*Eodrillia lonsdalei* (Lea)
						S			*Lyrosurcula funiculigera* (Cossmann)
							C		*Raphitoma venusta* (Lea)
								G	*Cochlespirella insignifica* (Heilprin)
				B^1	B^2	S		G	*Hastula venusta* (Lea)
				B^1					*Terebra andrega* DeGregorio
						S			*Ringicula biplicata* (Lea)
						S			*Acteon punctatus* Lea
	U		W	B^1		S			*Tornatellaea* sp.
				B^1	B^2	S	C	G	*Cylichnina galba* (Conrad)
M		Y?							*Cylichna jacksonensis* (Meyer)
								G	"*Bulla*" *dekayi* Lea
						S			"*Planaria*" *nitens* Lea

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PERMIAN FUSULINES FROM CENTRAL AMERICA

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ABSTRACT—Describes two species, *Parafusulina guatemalaensis* n. sp. and *P. sapperi* (Staff), which establish the Middle Permian age of the "Carboniferous limestone" of Guatemala.

CARL SAPPER spent the years 1888–1897 in Central America and in 1899 published a paper entitled, "Über Gebirgsbau und Boden des nordlichen Mittelamerika" He mapped a narrow belt of "Karbonkalk" running east-west across Guatemala in the latitude of San Cristobal, and from this formation he collected, among other fossils, a few lots of fusulines, which were turned over to E. Schellwien for study. The lamented death of the latter left the material to be reported on by von Staff, who described a single form as *Fusulina verneuili* var. *sapperi*. Unfortunately, Staff's description was very brief, but his illustrations are excellent so far as they go.

In 1928 Professor Schuchert was reviewing the geology of the region and, through the kindness of Dr. F. Broili, was able to borrow Sapper's collections, which had been deposited at Munich. Thus I came to have the opportunity to re-examine the fusulines from Guatemala, and I wish to express my obligation to both Professor Schuchert and Dr. Broili.

Three of the lots of Sapper's fossils contain fusulines. The localities of these are indicated as follows: 1, Purula (Alta Verapaz); 2, Trece Aguas; 3, Esperanza, Dept. of Alta Verapaz. All three lots are in a calcareous mudstone, which in the first two is dark grey and in the last appears reddish (probably due to discoloration during weathering). Lots 1 and 3 contain the same species, described herein as *Parafusulina guatemalaensis;* Lot 2 includes Staff's form, which is redescribed as *Parafusulina sapperi* (Staff). Although both species are unknown outside Guatemala, they are rather closely allied to certain species in the Permian of Texas, and both are in the stage of specialization represented by *Parafusulina*. They are without any doubt of Permian age, and are probably of the age of the Leonard formation (possibly the Word) of Texas.

My preliminary identifications of this material were quoted by Professor Charles Schuchert (1935). At that time I had not observed the cuniculi in the form then identified as *Pseudofusulina* and here described as *Parafusulina guatemalaensis*. Full and careful study has established the present reference, but the septal evolution represents a primitive stage in *Parafusulina*.

PARAFUSULINA SAPPERI (Staff)

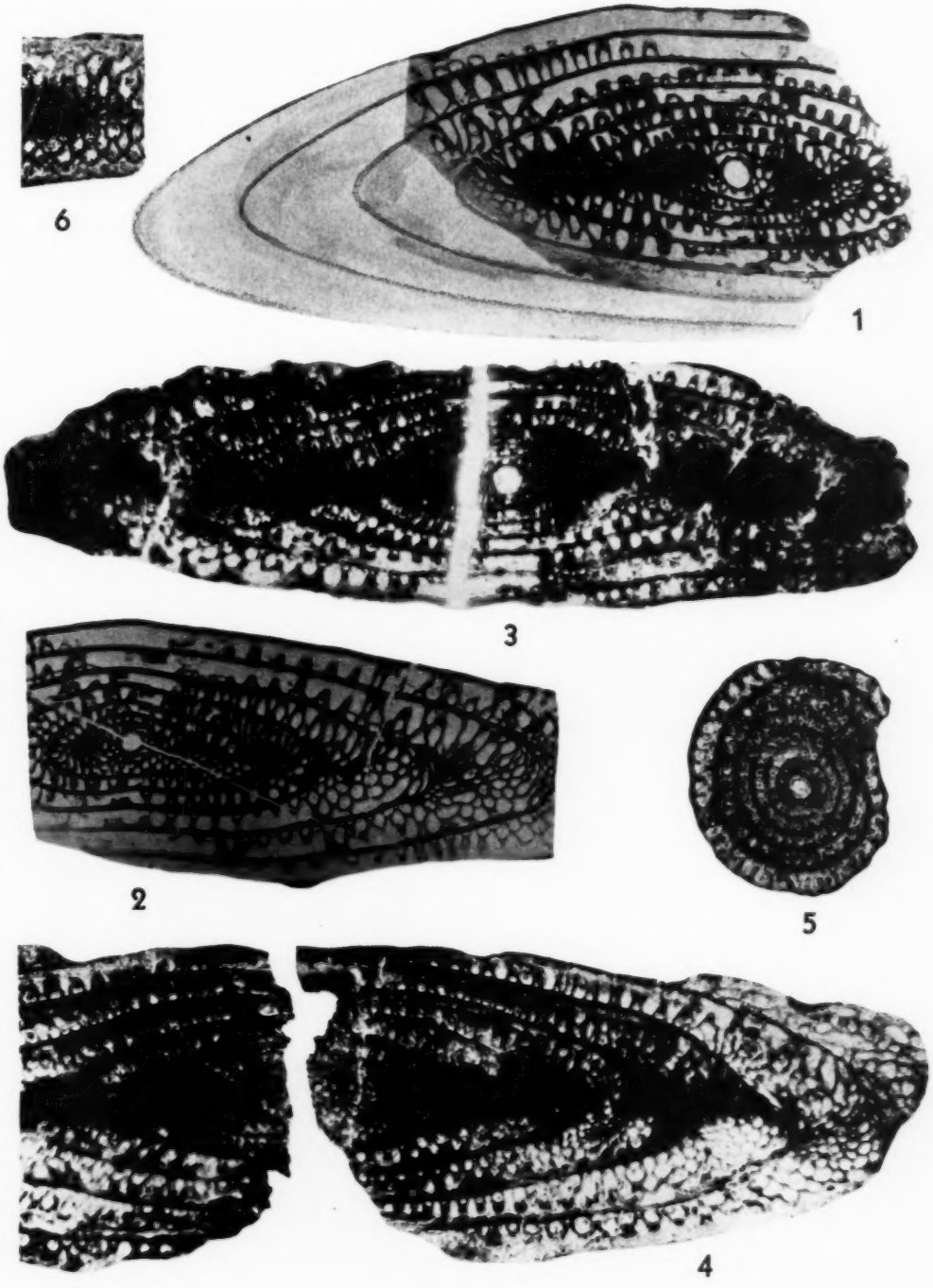
Plate 35, figures 1–6

Fusulina verneuili var. *sapperi* Staff, *1912*, Monographie der Fusulinen; Teil 3, Die Fusulinen (Schellwienien) Nordamerikas: Paleontographica, vol. 49, pp. 181–183, pl. 19, figs. 8, 9, 11 and (?) 13.

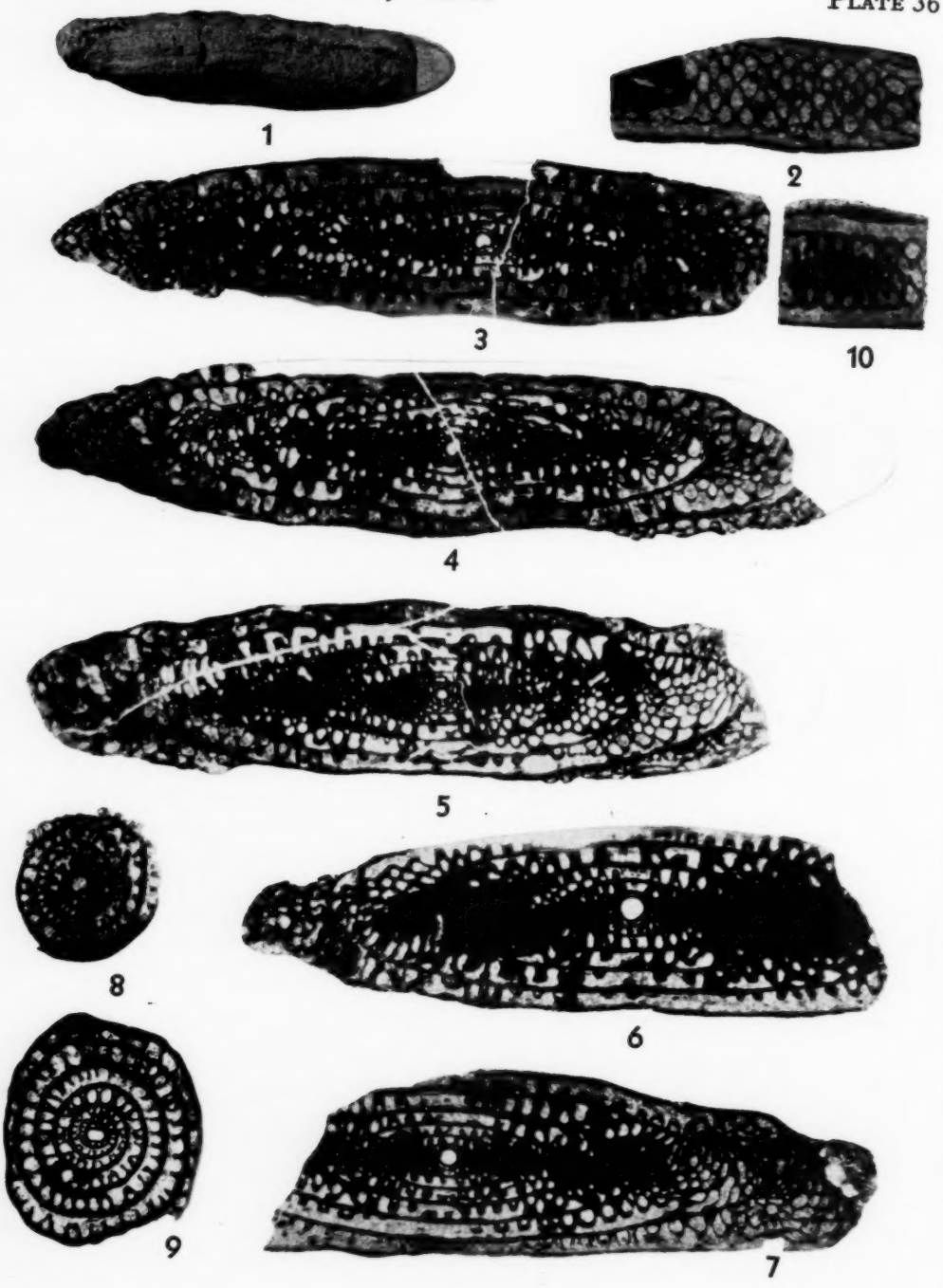
Staff did not give an adequate description of this species. He had before him specimens from Alaska and from Guatemala which he regarded as mere varieties of the Russian species *Fusulina verneuili* Möller, and as his interest centered chiefly

EXPLANATION OF PLATE 35

FIGS. *1–6*—*Parafusulina sapperi* (Staff), all ×10. *1*, Holotype axial section. This is a copy of Staff's pl. 19, fig. 11, reduced and restored in outline at the left end. Without this restoration the shell appears relatively much shorter and thicker than it really was. *2*, Staff's pl. 19, fig. 13, considered by the present wirter as uncertainly conspecific with the holotype. Reduced from ×15. *3, 4*, Axial sections. *5*, Sagittal section. *6*, Bit of a tangential slice showing the cuniculi. These specimens are silicified and photograph badly. The septa have been slightly retouched. (p. 344)



Dunbar, Permian Fusilines



Dunbar, Permian Fusilines

in the wide distribution of this species and its variants, he discussed them all together but failed to describe either form. Pertinent comments are limited to the following sentences:

> To Schellwien's conclusions [on the nature of *F. verneuili*] it may be added that the Central American type includes uncommonly large, fully developed individuals whose size exceeds somewhat that of the Russian form. With an axial length of about 11 to 14 mm these thickly fusiform shells reach a thickness of 5 mm. . . . Instead of Schellwien's maximum of .27 mm [for the diameter of the proloculum] it reaches to about .53 mm in macrospheric individuals. . . . Finally, concerning the relations of the Alaskan fusuline to that from Central America it is to be noted that the form from Guatemala through its somewhat distinctive, inflated habitus, its exceptional size, and its strongly preponderant megalospheric forms, may be separated as a variety (var. *sapperi*), while the Alaskan form corresponds completely to the Russian type.

Four illustrations were given of the Guatemalan fusuline, all at a magnification ×15. Of these, figures 11 and 13 are axial sections, which appear to differ considerably. I therefore designate as holotype the axial section represented by figure 11. It is chosen because it corresponds best with Staff's discussion. At first glimpse figure 13 appears to represent a much more elongate shell, but when the end of figure 11 is restored according to the natural contour (my plate 35, figure 1) the resemblance of the two is much closer. Nevertheless, the specimen represented by Staff's figure 13 has a smaller proloculum and less conspicuous axial filling than the holotype. Whether it represents a distinct variety or a normal variant of the species cannot be decided without the examination of more material. Figures 8 and 9 of Staff show sagittal sections which agree well with the holotype in so far as we may judge from the height of successive volutions and the great size of the prolocula.

Unfortunately Staff did not indicate the locality in Guatemala from which Sapper collected the specimen represented by his figure 11; the other figured specimens were from Panzal, which is near Esperanza. Staff indicated that his thin sections were at Königsberg. The rest of Sapper's collections, however, were left at Munich, and of the three fusuline collections before me only one, that from Trece Aguas, includes shells that can be referred to *sapperi*. These specimens are silicified and lie imbedded in a dark grey mudstone. The following description is based upon Sapper's illustrations and upon the material from Trece Aguas.

Description.—The species is rather thickly fusiform with convex lateral slopes and narrowly rounded poles. Adult shells have 6 to 7 volutions and attain a length of 15.0 to 18.0 mm and a thickness of about 5.0 mm. Being broken at both ends, the holotype appears shorter than it actually was. Staff's figure has been reduced to a magnification of ×10 and the outline of one end has been restored as plate 35, figure 1. The form ratio is between 2.0 and 2.5 in the first 2 volutions and tends to increase to 3.5 or 4.0 at maturity.

The proloculum is commonly very large, measuring about 460 microns in diameter in the holotype, about 450 microns in one of Staff's sagittal sections and 600 in the other, and near 400 microns in three measured specimens before me. In the specimen represented by Staff's figure 13, however, the diameter is only about 370 microns.

The height of the whorls increases gradually but rather rapidly, and the height of each volution also increases from the equator to the poles. The spiral wall is distinctly alveolar and of moderate thickness, increasing gradually from about 45 microns in the second whorl to near 130 microns thick in the outer volution.

The septa are regularly and strongly folded but are rather widely spaced. Accordingly the septal loops are high and narrow, except where, in some volutions for a distance near the middle of the shell, the

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EXPLANATION OF PLATE 36

FIGS. *1–10*—***Parafusulina guatemalaensis*** Dunbar. All from an unnamed limestone of Middle Permian age near Purula (Alta Verapaz), Guatemala. *1*, Exterior view of a cotype, ×5. *2*, *10*, Sagittal slices, ×10, the first cut a little above the cuniculi, the second showing well the cuniculi. Neither is retouched. *3–7*, Axial sections of cotypes, ×10. *8*, *9*, Sagittal sections, ×10.

(p. 347)

slice happens to be well centered between septa, and there the loops appear low. Tangential sections show well-developed, though rather slender, cuniculi and prove the generic assignment to *Parafusulina*. Chomata are entirely obsolete, but a rather conspicuous secondary deposit occupies the axial zone. This deposit is irregularly distributed and apparently somewhat unequally developed in different specimens. In the holotype it was conspicuous, but in the associated specimen (Staff's figure 13) it is but slightly developed.

filling. All our sections of *P. schucherti* have prolocula smaller than the Guatemalan form; also the average, as well as the maximum size is somewhat less in the Texas species; and the mature form ratio is less than 3.0 in the latter and as much as 3.5 or 4.0 in *P. sapperi;* finally, the septal count increases steadily to about 50 in the outer whorl of *P. schucherti* but is less than 40 in corresponding whorls of *P. sapperi.*

P. diabloensis agrees better with Staff's species in the size of the proloculum, but the radius vector increases a little more rap-

TABLE OF MEASUREMENTS

	Half length (millimeters)					Radius vector					Form ratio				
	1[1]	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0	.23	.17	.21	.31	—	.24	.19	.23	.21	.26	—	—	—	—	—
1	1.00	?	—	.71	—	.40	.30	.36	.34	.43	2.5	—	—	—	—
2	1.50	1.33	1.16	1.16	—	.60	.52	.54	.51	.63	2.5	2.5+	2.1	2.3	—
3	2.13	2.00	1.95	1.85	1.92	.80	.70	.79	.76	.84	2.6	2.9−	2.5	2.4	2.3
4	2.90	2.67	2.75	3.07	3.2	1.05	.93	1.30	1.04	1.11	2.8−	3.0	2.1	3.0	2.8
5	4.00	4.47	3.86?	—	4.6	1.40	1.23	1.64	1.34	1.40	2.8+	3.6	2.4	—	3.3
6	5.00?	6.00	5.14?	5.70	6.2	1.80	1.60	—	1.61	1.72	2.8−	3.7	—	3.5	3.6
7	—	7.73?	6.07?	7.0?	7.6	2.17?	1.97	—	2.01+	—	—	4.0	—	3.5	—

	Tunnel angle (degrees)					Wall thickness (millimeters)					Septal count		
	1	2	3	4	5	1	2	3	4	5	6	7	8
1	—	—	—	—	—	—	—	—	—	—	15	15	18
2	26?	—	29	—	—	—	—	.045	—	.065	25	25	23
3	—	32	33	—	29	—	—	.065	.060	.065	25	28	26
4	29	37	34	—	35	—	—	.075	.105	.095	24	31	32
5	34	37	39	—	33	—	—	.120	—	.120	29	?	33
6	50?	—	40	—	37	—	—	.130	.135	—	31	?	37
7	—	—	—	—	—	—	—	—	—	—	36	—	—
8	—	—	—	—	—	—	—	—	—	—	38	—	—

[1] Specimen 1 is the holotype and the measurements are deduced from Staff's figure 11; specimen 2 is the paratype represented by Staff's figure 13; specimens 3–5 are from Sapper's lot from Trece Aguas; specimens 6 and 7 are paratypes (Staff's figures 8 and 9), and specimen 8 is from the lot at Trece Aguas. Specimens 1, 2, 3, 4 and 8 are illustrated on my plate 35 as figures 1, 2, 3, 4 and 5, respectively.

It was not practicable to measure the wall thickness in Staff's illustrations but it is evident from these figures that the original types agree well with those before me in this respect.

Discussion.—Unfortunately this species is not known in the Permian section of Texas and New Mexico. It resembles *P. schucherti* Dunbar and Skinner and *P. diabloensis* Dunbar and Skinner, both of which have a similar shape and heavy axial

idly and the length more slowly in the Texas shell, which has a form ratio less than 3.0 at maturity. The resemblance to these two species of Leonard age is, however, closer than that to any other American species.

P. splendens, of the Word formation in Texas, is the next closest American species, having similar shape and comparable axial deposits. It has large prolocula, as does *P. sapperi*, but its axial deposits are somewhat heavier and are concentrated nearer

the middle of the shell; the average size of *P. splendens* also is inferior and its form a little more slender. Also its septal folding is a little more advanced, the cuniculi being broad and conspicuous, whereas in the Guatemalan shells they are narrow and low.

The resemblance of the Central American shells to *Fusulina verneuili* Möller is only general and, according to modern refinements, does not justify their suppression as a variety of the latter. We are indebted to Vissarionova (1937) for a recent critical study of the Russian species, and it is clear that the true *F. verneuili* of Möller is a smaller and less highly evolved fusuline lacking cuniculi. It was correctly referred to *Pseudofusulina* (now = *Schwagerina* [sensu vera]), whereas the Guatemalan species is a true *Parafusulina*.

Occurrence.—Sapper collected this species at Trece Aguas and at Panzal, Guatemala. The horizon is Middle Permian, i.e., Leonard, or possibly Word, in age.

PARAFUSULINA GUATEMALAENSIS
Dunbar, n. sp.
Plate 36, figures 1–10

Description.—An elongate fusiform species of 5½ to 6½ volutions, attaining a length of 11 to 12 mm and a diameter of about 2.5 mm. The form ratio is between 2.0 and 3.0 in the second volution and increases to nearly 4.0 in the fifth whorl and exceeds 4.0 in the sixth.

The proloculum ranges between 246 and 370 microns in diameter in our sections but is commonly between 250 and 300 microns. Although commonly subspherical, it appears notably flattened in one of our figured specimens and subcordate in another. The wall of the proloculum is exceptionally thick, measuring 45 to 50 microns, whereas that of the first whorl is not over 25 or 30 microns.

The volutions increase gradually in height, and the wall thickens to a maximum of about 100 microns in the outer whorl. The wall is coarsely and very distinctly alveolar, and pores much finer than the alveoli can be seen to pass through the tectum.

The septa are regularly and intensely folded so that opposed folds meet and unite as in *Parafusulina*, but the cuniculi are very low and narrow and are easily overlooked. The septa increase in successive volutions from about 14 in the first to between 30 and 40 in the fifth. Septal pores are numerous. The tunnel is low and wide, the tunnel angle exceeding 70° in the last whorl of two of the types. As shown in the table of measurements, the angle varies considerably among the types. There is no trace of chomata but a conspicuous secondary deposit takes the form of an irregularly distributed axial filling.

Discussion.—This species is smaller and much more slender than *P. sapperi*, the other known Guatemalan species. Furthermore, it has a smaller proloculum and lower volutions. It somewhat resembles *P. splendens* Dunbar and Skinner of the Word formation of Texas but is rather more slender, less pointed at the poles, has a narrower tunnel, smaller average size of the proloculum, and less specialized septa, its cuniculi being smaller than those of the Texas species. The resemblance to another Word species, *P. bösei* var. *attenuata* Dunbar and Skinner, is also noteworthy, but the latter is somewhat larger at corresponding volutions, has less axial filling, rather fewer septa, and more advanced septal fluting with larger cuniculi. *P. bakeri* Dunbar and Skinner from the lower part of the Leonard formation is a thicker shell with a larger proloculum, a narrower tunnel and less axial filling. *P. fountaini* of the Bone Spring limestone of the Guatelupe region, Texas, is also similar in proportions and shows about the same stage of septal specialization, but it attains a much larger size than the Guatemalan species, has a much larger proloculum, and possesses almost no axial filling.

This is the species labeled *Fusulina granumavenae* in Sapper's collection and so listed by Schuchert (1935, p. 340). The resemblance to that species is not close enough to justify comparison.

Occurrence.—The types are all from Sapper's locality near Purula (Alta Verapaz), Guatemala. The species is also abundant in his collection from Esperanza in the same department of Guatemala. This material is in the Institut für Paläontologie und Historische Geologie at Munich, Germany.

TABLE OF MEASUREMENTS

	Half length (millimeters)				Radius vector				Form ratio			
	1[1]	2	3	4	1	2	3	4	1	2	3	4
0	.137	.130	.123	.143	.137	.130	.123	.143	—	—	—	—
1	.43	.29	.43	.47	.20	.19	.26	.29	2.1	1.5	1.7	1.6
2	1.01	.60	.97	.96	.36	.29	.41	.46	2.8	2.1	2.3	2.1
3	1.52	1.10	1.85	1.82	.57	.44	.64	.67	2.7	2.5	2.9	2.7
4	3.00	1.87	2.97	2.64	.81	.60	.87	.94	3.7	3.1	3.4	2.8
5	4.00	3.45	4.36	4.43	1.11	.84	1.14	1.23	3.6	4.1	3.8	3.6
6	?	5.6+	5.7+	6.0?	—	1.07	—	1.43	—	5.2	—	4.2?

	Tunnel angle (degrees)				Wall thickness (millimeters)				Septal count	
	1	2	3	4	1	2	3	4	5	6
1	—	—	40	—	—	—	.025	.030	14	14
2	50	—	47	33	.035	.035	.050	.030	21	26
3	52	—	43	36	.050	.040	.055	.045	24	30
4	41	—	48	47	.090	.055	.075	.075	34	30
5	55	48	51	71	.110	.090	.085	.090	32	34?
6	72	66	—	—	—	.110	—	.100	38	?
7									?	

[1] Specimens numbered 1 to 6 are illustrated on plate 36 as figures 3, 4, 5, 7, 9 and 8, respectively. The measurements for no. 2 are systematically less than those of corresponding volutions of the other three, although the proportions of length to thickness agree well; it is evident that the orientation of the section is such that the measurements for specimen no. 2 are not at the end of successive volutions but appreciably less.

The same species is present in a collection made by Sidney Powers along the south bank of Polochie River near Pancajche. The latter collection is in the Museum of Comparative Zoology at Harvard, and I am indebted to Prof. Percy E. Raymond for the opportunity to examine it.

Since the cuniculi are so low and narrow, it is evident that the septal evolution is primitive for *Parafusulina*, and the age is probably that of the Leonard formation or the Bone Spring limestone of Texas.

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JOURNAL OF PALEONTOLOGY, VOL. 13, NO. 3, PP. 349–353, 4 TEXT FIGS., MAY, 1939

A CRANIUM OF PLIOHIPPUS FOSSULATUS[1] FROM THE CLARENDON LOWER PLIOCENE FAUNA OF TEXAS

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ABSTRACT—A cranium of a female *Pliohippus fossulatus* Cope is described from the Clarendon lower Pliocene fauna of Texas. The preorbital fossae are more deeply developed than in any horse cranium known to the authors. Comparison is made with other species in the genus.

REMAINS OF *Pliohippus* are perhaps more common in American Pliocene deposits than any other genus of horses. Yet the intergeneric relationships of the named species are not yet satisfactorily interpreted. That different groups are represented in the genus now seems obvious, but the exact allocation of all of the species into these groups is almost, or quite, impossible at present. Eleven of the 19 types are isolated teeth, six are maxillaries or other parts of the skull, whereas only two are based on complete skulls and one of these is immature. To date the only reliable specific comparisons that have been made are based on series of isolated teeth, maxillary and mandibular tooth rows and cannon bones. Some fairly accurate results have been obtained by this method when variation due to different stages of wear, position in the jaws, and normal variation have been considered. In several species, however, not enough topotypic material is available for study. The addition of cranial characters should help considerably in substantiating characters already observed in the teeth and limbs. It seems advisable, therefore, to place on record the description and figures of a female cranium recently found in the Clarendon lower Pliocene fauna by the junior author.

[1] Though Cope's types of *Pliohippus pachyops* and *P. fossulatus* were found at the same locality and evidently represent the same species, it seems inadvisable to attempt to eliminate one of the names until the relationships to closely related forms such as *pernix*, *robustus*, and *tantalus* can be established.

The cranium was discovered in July 1937 in the Clarendon area of the Ogallala formation. It was found at the base of a 35-foot bank in a conglomerate lens in a brown clay bed 300 yards left of the crossing of the north-south highway over Whitefish Creek 2 miles south of Allanreed, in the NW ¼ sec. 21, Block E, Donley County, Texas.

Acknowledgment is made of the assistance received from the Federal Works Progress Administration in the preparation of the specimen and manuscript. The illustrations are those of the museum artist, Owen J. Poe.

DESCRIPTION

The conglomerate is well-indurated, particularly next to the bone surface. This, together with a decayed and checked condition of the bone rendered the specimen extremely difficult to prepare. We were not able to clean all of the matrix from the deep recesses of the lacrymal and malar fossae without endangering the outer surface. Then, too, in certain parts of the basicranial area, we deemed it advisable not to spend time in removing this difficult matrix.

This is the best horse cranium that we have seen in the Clarendon fauna; but even in this specimen, part of the premaxillaries and some of the basicranial processes were broken away before or at the time the specimen was buried.

The cranium is about average in size among the known species of *Pliohippus*. Its dorsal outline displays a somewhat rounded appearance with the highest point between the orbits. From this point it slants off in

every direction. Though the frontal region is convex, there is a median depression on the dorsal surface opposite the anterior rims of the orbits. Gidley (1907, p. 195) mentions this character in his study of the type of *Pliohippus fossulatus*. In the type, the depression is slightly more posterior in position. There is a certain amount of crushing in the specimen at hand; but the presence of a normal depression seems unquestionable.

The nasal bones appear to be constricted above the lacrymal fossae. Actually it is the lower margin of these bones, which expand laterally in the rostral region, that gives the bones a much more widened appearance anteriorly. Though ends of the nasals are broken away, the narial notch is observed to be above the mesostyle of P^2. The premaxillaries end exactly 80.0 mm back of the narial notch in a rather blunt but irregular sutural line.

The most outstanding features are the size and depth of the preorbital fossae. The lacrymal fossa is the largest and extends dorsoposteriorly, 200 mm or more, into a deep pocket. It is well-outlined, but not pocketed anteriorly. Its outline is oval dorsally but forms a straight line along its lower edge. An irregular floor is represented with one prominent ridge extending across the lower edge of the fossa. The front edge of the fossa is directly above the anterior edge of P^4, and the posterior rim is above the parastyle of M^3. Its rim is 84.5 mm long and 40.0 mm wide.

The malar fossa has a more rounded outline than the lacrymal fossa. It extends into a deep pocket posteroventrally, 28.0 mm or more, and it also extends from 12.0 mm to 20.0 mm below the lower edge of the fossa rim. A prominent septum extending down from the posterior edge of the lacrymal fossa divides the malar fossa into two unequal parts. This septum tends to disappear before it reaches the prominent maxillary border. The anterior pocket is about the size of a large, deep thumb print. In the floor of the posterior division are two small ridges formed by the mesostyle of M^2 and the parastyle of M^3. The posterior rim of the fossa lies above the middle of M^3. The malar fossa is 64.0 mm long and 40.0 mm wide.

The smaller maxillary fossa is directly in front of the infraorbital foramen. It is slightly smaller and shallower than the anterior pocket in the malar fossa, and its direction is forward and downward.

These three fossae outlined by a heart-shaped outer rim occupy most of the lateral facial area above P^4-M^3. In front of this area, directly above P^{2-3} and below the naso-maxillary suture, a shallow fossa extends down into the buccal fossa area. The posterior margin of the buccal fossa is not as sharply outlined above the edge of P^1 as in *P. interpolatus*. On the whole, the facial fossae in this specimen display a greater development than in any horse cranium on record with the possible exception of the type of *Archaeohippus ultimus*.

Gregory (1920) concludes that the lacrymal fossa probably lodged a greatly expanded nasal diverticulum. It is assumed here that if a nasal diverticulum was lodged in the lacrymal fossa of this cranium, another branch must have extended into the malar fossa, since there is no indication for the presence of an enlarged maxilla-labialio superior muscle along the front of the premaxillary. The muscle must have arisen, then, from the edges of the fossa. W. D. Matthew suggested that the origin of these preorbital fossae may be correlated with the uprising of stiffening ridges and eminences above and below the fossae and with the hollowing out of the parts not so strengthened. The specimen at hand indicates that deep preorbital fossae are not peculiar to males.

The orbit seems to be directed as much anteriorly as in most living horses. Thus the posterior rim extends 22 mm farther laterally than the anterior rim, and the vertical diameter of the orbit exceeds the transverse by 9 mm. In contrast to the later horses, the anterior border of the orbit is above the posterior edge of M^3. A narrow maxillary rim (9.0 mm) outlines the lower border of the orbit. Continuing anteriorly, the maxillary ridge is prominent and extends to a position above the parastyle of M^1. Posteriorly, the maxillary bone continues as a sliverlike bone to a point below the anterior part of the temporal fenestra. The infraorbital foramen also is above the parastyle of M^1. Supratemporal foramina are located 18 mm in a

posteromedian direction from the highest orbital point. The brain case is relatively as wide (74.0 mm) as in *P. interpolatus*. But the supratemporal ridges are not as prominent and unite into inconspicuous sagittal crests opposite the posterior extension of the zygomatic arch. The supratemporal crest is partly broken, but there is no pronounced pocket below the crest as in *P. interpolatus*. A basal part of the left tympanic is preserved. It has a rather wide base (15.0 mm) and probably diverged slightly from the condyles. The distance between the postpalatine notch and the vomerine notch is one-third greater than the space between the vomerine notch and the edge of the foramen magnum. Cryptocephally, or the bending of the basicranial upon the facial axis, is about 29°.

Widths of the palate between the lingual edges of the protocones of M^3 and P^2 are 59.0 mm and 36.0 mm respectively, and the postpalatine notches are opposite the middle of M^2. The palatal region is abruptly elevated at the anterior edge of the cheek-tooth series.

The dental characters are very close to those in the type of *Pliohippus fossulatus*. There is a small alveolus for the canine on the right side, indicating that the specimen was a female. P^1 is larger than in any other *Pliohippus* that we have seen. It is 18 mm long and 10 mm wide. The other cheekteeth are well-worn with protocones broadly connected to the protoselenes. The premolars and the last molar are longer than they are wide whereas M^{1-2} are wider than long. On P^{2-4} the protocones are nearly round, whereas on M^{1-3} they are more elongate and pointed. On M^{1-2} the protocones are connected both to the protoselene and metaselene. This has frequently been used as a distinctive character of *Protohippus*. In the premolars the fossettes are more elongate but not as deep transversely as on the molars; there are no plications on the fossette borders and on P^2 the fossettes are connected. Postprotoconal valley invaginations of moderate depth and with no plicaballin fold. The styles are moderately heavy, but a rather strong curvature is indicated in the teeth.

COMPARISON WITH OTHER SPECIES

The specimen at hand compares almost in detail with Cope's type of *Pliohippus fossulatus*. The preorbital fossae are larger and much more deeply extended; then, too, there are some minor differences in other parts of the cranium and in the dentition. But other resemblances are so profound that it is probable that this specimen is referable

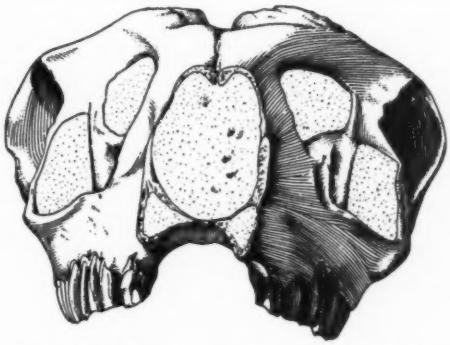
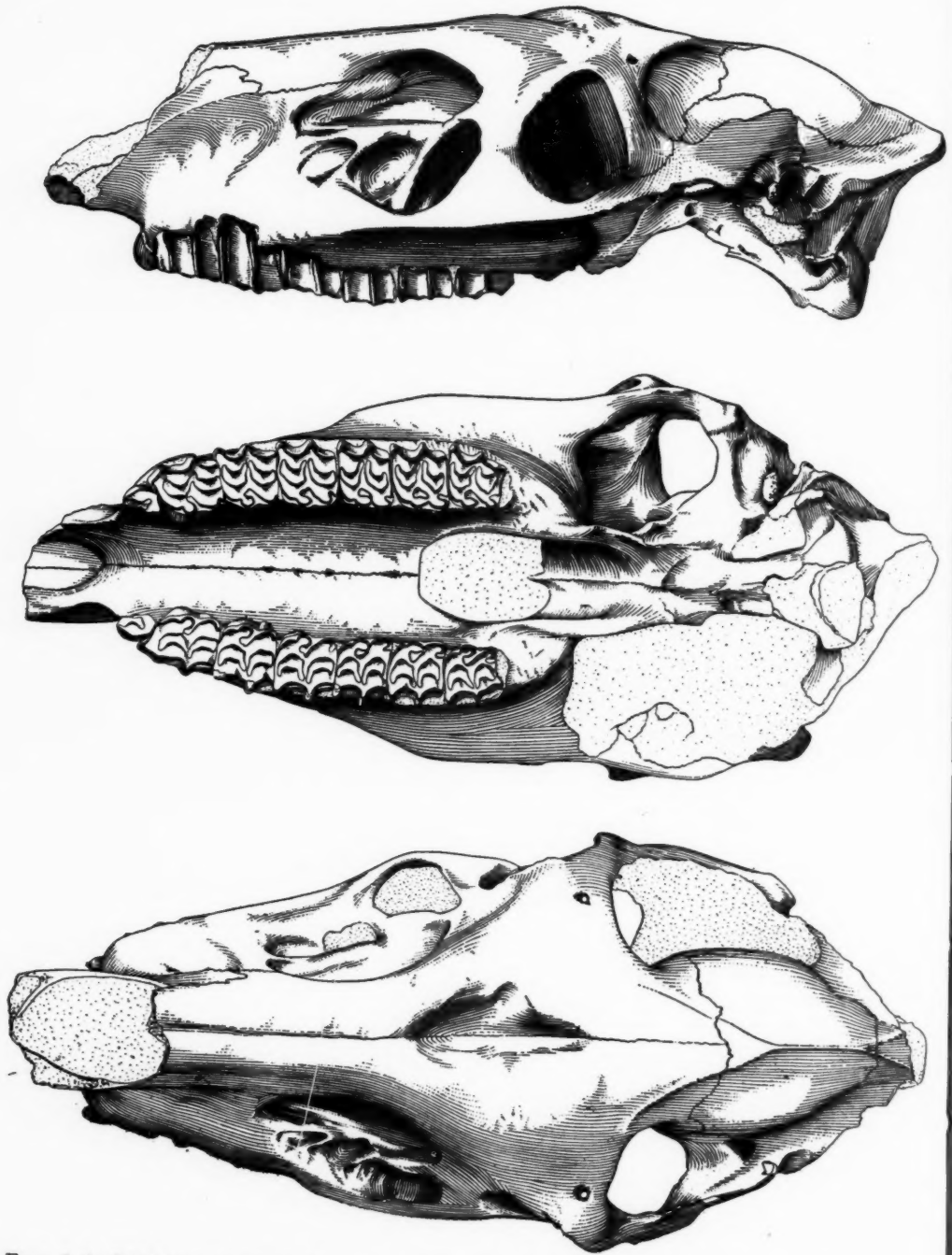


FIG. 1.—*Pliohippus fossulatus* (Cope). Cranium of female, ×¼. Univ. California Mus. Paleontology 3348.

to Cope's species. It should, however, be pointed out that we have found no reliable distinctive characters to differentiate the species *pernix*, *robustus*, *spectans*, *fossulatus*, *pachyops*, *tantalus* and *fairbanksi*. Furthermore, the faunas in which these types are included are of approximately the same age though they occur in Nebraska, Texas, Oregon and California. *P. spectans* is probably more recent than the others. Though *fossulatus* is sometimes considered a synonym of *pachyops*, and *fairbanksi*, a synonym of *tantalus*, the other types have not been critically compared. Some of these types may represent distinct forms, but this needs to be demonstrated by additional topotypic material.

P. lullianus is larger and longer limbed, with heavier lateral metacarpals than in *P. pernix*. The milk teeth, however, are about equal in size to those that have been referred to *P. pachyops*. The South Dakota type agrees further with the specimen at hand in having a large P^1.

P. tehonensis and *P. supremus*, when compared from a series of teeth, are slightly smaller and shorter-crowned than the late lower Pliocene specimens. This is particularly true of the latter, in which there is a frequent isolation of the protocone.



FIGS. *2–4—Pliohippus fossulatus* (Cope). Cranium of female, ×½. Univ. California Mus. Paleontology 33481. *2*, Left lateral view, *3*, Ventral view, *4*, Dorsal view.

The relationship of *P. edensis* and *P. castelli* is uncertain. From what is known of the types, they seem to be little, if any, more advanced than the most primitive species known to the genus, yet they occur in middle Pliocene assemblages. Possibly they are primitive carryovers as is commonly evidenced in other groups.

P. nobilis is the largest of the described species, but otherwise it seems to differ very little from *P. fossulatus*. Apparently the type of *nobilis* came from a middle (?) Pliocene assemblage in Kansas; yet we find *Pliohippus* teeth equally as large as *nobilis* in lower Pliocene faunas in California.

The middle Pliocene species *interpolatus* and *leidyanus* have higher-crowned teeth, which are relatively more slender than in *fossulatus*. The protocones, also, are more elongate and pointed, the buccal fossae are deeper, and the dorsal profile of the skull is more flattened. In these later species, the preorbital fossae are shallow or obsolete. The distinctions between *interpolatus* and *leidyanus*, however, are not clear. The preorbital fossae in an adult male skull of *interpolatus* from the Hemphill fauna are not more developed than in the female type of *leidyanus*.

P. coalingensis is not well known; one unworn cheek tooth is the type. It differs from the other known species of *Pliohippus* in its straighter crown and relatively small lingually directed protocone. Except for the size and shape of the protocone, it might be considered as being closely related to the upper Pliocene species of *Equus*. The species *Pliohippus* (*Astrohippus*)[2] *martini* (Hesse), originally referred to *Calippus*, *P. ansae* (Matthew and Stirton), originally referred to *Protohippus*, and *P. osborni* represent another group of pliohippine horses that display definite pre-*Equus* characters in the dentition. This is particularly true in *ansae* and *osborni*, whereas *martini* is practically intermediate between *Merychippus* (*Protohippus*) *perditus* from the upper Miocene and *Pliohippus* (*Astrohippus*) *ansae* from the middle Pliocene. These species are smaller than contemporary species of true *Pliohippus*.

CRANIAL MEASUREMENTS
(in millimeters)

1. Posterior edge of narial notch to anterior border of orbit.....	147
2. Anterior border of orbit to posterior border of auditory meatus,	142
3. Greatest width at posterior edge of orbits.....	169
4. Width between outer edges of glenoid fossae.....	159
5. Length from anterior edge of P^2 to posterior border of auditory meatus.....	246
6. Width of palate from inner alveolar border of P^4,.....	54
7. Greatest width of brain case,....	84
8. Width between upper edge of infraorbital foramina.....	?84
9. Depth of skull above P^4, (from alveolar border).....	111
10. Length and width of orbit,.....	57

11. Length *$P^1-M^3=171.3$; $P^1-M^2=145.1$; $P^1-M^1=120.5$; $P^1-P^4=98.4$; $P^1-P^3=71.7$; P^1-P^2 45.4; **$P^2-M^3=157.0$; $P^2-M^2=132.0$; $P^2-M^1=107.6$; $P^2-P^4=84.8$; $P^2-P^3=58.0=P^3-M^3=127.9=P^3-M^2=102.1$; $P^3-M^1=77.3$; $P^3-P^4=54.3$; $P^4-M^3=101.4$; $P^4-M^2=75.3$; $P^4-M^1=50.3$; $M^1-M^3=74.6$; $M^1-M^2=47.8$; $M^2-M^3=51.1$

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[2] The type of the subgenus is *Protohippus ansae*. For discussion and relationships see Stirton's Phylogeny of North American Equidae. Univ. California, Dept. Geol. Sci., Bull. *In Press.*

* From anterior edge of P^1 to posterior edge of metastyle.

** From anterior edge of parastyle to posterior edge of metastyle.

NOTE: Manuscript received by the Editor September 24, 1938.

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ARCA (NOETIA) VEATCHITES, NEW NAME FOR A. (N.) VEATCHI CASTER, 1938

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DR. PHILIP W. REINHARDT of Los Angeles has recently called my attention to the fact that the name *Arca* (*Noetia*) *veatchi* Caster, 1938,[1] applied to a fossil from the Quimbriz (Eocene) formation on the Luculo River, Portuguese West Africa, is preoccupied by *Arca veatchi* Olsson, 1922, from the Gatun formation of Costa Rica. I am grateful to Dr. Reinhardt for calling my attention to the absolute homonym, and here propose to substitute for the West African species the name *Arca* (*Noetia*) *veatchites*. By this specific name I wish to continue the slight tribute to the memory of Dr. A. C. Veatch, who collected my original material in Africa.

[1] CASTER, K. E., *1938*, Macroscopic fauna of the Quimbriz (Eocene) formation on the Luculo River, Angola: *Serviços Geol. Portugal, Communicaçoes*, vol. 20, p. 12, pl. 2, figs. 1–3.

JOURNAL OF PALEONTOLOGY, VOL. 13, NO. 3, P. 354, MAY, 1939

LINOBRACHIOCRINUS, NEW NAME FOR LINOCRINUS GOLDRING, 1938, NOT KIRK, 1938

WINIFRED GOLDRING
New York State Museum, Albany, New York

IN A RECENT paper on Devonian crinoids from the Mackenzie River Basin (1) the writer proposed the name *Linocrinus* for a new genus of crinoids, using as genotype the new species *kindlei* Goldring, unaware that Dr. Edwin Kirk (2) was proposing the same generic name for a different genus. As his paper was published four months before mine, I propose to replace *Linocrinus* Goldring by *Linobrachiocrinus*, retaining *Linocrinus kindlei* as the genotype. The new generic name is derived from the Greek *linon*, strand (of a rope), and *brachion*, an arm, and is suggested by the resemblance of the long arms of the genotype to the strands of an unravelled rope.

My thanks are due to Dr. R. S. Bassler for calling my attention to the previous use of the name *Linocrinus*.

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2. KIRK, EDWIN, *April 15, 1938*, Five new genera of Carboniferous Crinoidea Inadunata: *Washington Acad. Sci., Jour.*, vol. 28, no. 4, p. 168.

JOURNAL OF PALEONTOLOGY, VOL. 13, NO. 3, PP. 355–360, PL. 37, MAY, 1939

FRESH-WATER INVERTEBRATES AND LAND PLANTS OF CRETACEOUS AGE FROM EUREKA, NEVADA

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ABSTRACT—A fresh-water faunule from an unnamed formation originally supposed to be of Carboniferous age proves to be of Cretaceous age. The mollusks include one new genus of Sphaeriidae, *Musculiopsis*, three previously described species, three new species, and one new subspecies.

IN 1882 C. D. Walcott collected some fresh-water invertebrates and land plants from two localities in the Eureka district of Nevada, one at the northern end of Gorman Hill,[1] and the other just south of the town of Eureka near the western end of the ridge in back of the abandoned Richmond Smelter. An additional collection was made in 1938 by T. B. Nolan from a tunnel on the northeast slope of Gorman Hill about 1000 feet southeast of Walcott's locality.

All three collections were obtained from an unnamed formation composed in large part of fanglomerates and dense argillaceous limestones, but which includes beds of coarse, dark grits, and thin zones of shale. Hague (1892) considered the beds carrying these fossils to lie conformably beneath a considerable thickness of fossiliferous marine limestone of Carboniferous age, but said "it is to be regretted that their strike and dip could not be determined with precision." Recent mapping by the Geological Survey, however, has shown that the beds, which are considerably deformed locally, overlie the Carboniferous and older rocks with a marked unconformity which, together with the paleontological evidence given in this paper, indicates that they are much younger.

By comparison with other known fresh-water faunas the fauna of the new formation is of Cretaceous age, and, on the basis of closely related species of unionids and of a new *Musculium*-like genus, would appear to be of the approximate age of the lower Blairmore formation of southwestern Alberta, which is assigned to the Lower Cretaceous. Dr. Roland W. Brown of the Geological Survey has examined the plants from Eureka and reports that they, too, indicate a Lower Cretaceous age for the beds in question. He writes:

> There seems to be no record that the plants taken from the same beds as the invertebrates referred to in this paper were ever studied or identified. They are poorly preserved and few in species, but the following can be identified tentatively: *Gleichenia*, cf. *G. nordenskioldi* Heer; *Sequoia*, cf. *C. condita* Lesquereux; *Phyllites* sp.; and *Carpolithes* sp. The *Gleichenia* and *Sequoia* resemble most closely the species with which they are compared, which occur in the Cheyenne sandstone near Belvidere, Kansas. The position of the Cheyenne sandstone is said to be in the upper part of the Lower Cretaceous. The evidence of the plants, so far as it goes, therefore, apparently harmonizes with that of the invertebrates in denoting a Lower Cretaceous age for the beds in question.
>
> In the same drawer with the collection just referred to, is one specimen of palm, *Sabalites* sp., with the label "From White Pine shales, White Pine, Nevada. Found near the top of the horizon in a thin belt of sandstone in the shales. The White Pine shales belong to the top of the Devonian in Nevada. Collected by Arnold Hague." White Pine lies some 50 miles southeast of Eureka, and this palm with no further data as to its origin evidently is derived from a horizon that was only superficially correlated by the collector with the White Pine shales of the Eureka district. The specimen consists of a portion of the top of a broad petiole and the broken span of what was once a large fanshaped leaf. Similar well-recognizable palm remains are unknown from deposits earlier than Upper Cretaceous. It would seem, therefore, that this *Sabalites* specimen was collected from a higher horizon than the plants near Eureka, and certainly did not come from the White Pine shales, now classified by the Geological Survey as of Mississippian age.

The reassignment of age for these beds

[1] Known as New York Hill when Walcott's collections were made.

removes the need for assumption of shoreline or near-shore conditions for their supposed position in the Carboniferous section as stressed by Hague, and also takes from *Zaptychius carbonarius* Walcott and *Physa prisca* Walcott the distinction of being among the oldest known pulmonates. The recognition of a Cretaceous fresh-water fauna in this region, hundreds of miles from any previously known Cretaceous rocks, however, provides a much needed datum plane in the complex structural history of the Great Basin, and encourages the hope that additional occurrences of the fauna may be found in the province.

I am indebted to Dr. Paul Bartsch and Dr. J. P. Morrison of the Division of Mollusks of the U. S. National Museum for frequent consultations during the preparation of this paper.

SYSTEMATIC DESCRIPTIONS

Class PELECYPODA
Family UNIONIDAE
Subfamily UNIONINAE
Genus, PROTELLIPTIO Russell, 1934

Protelliptio RUSSELL, *1934*, Canadian Field Naturalist, vol. 48, no. 1, p. 2.

The name *Protelliptio* was proposed as a subgenus of *Elliptio* and made to include three Lower Cretaceous species, *Unio biornatus* Russell, the type, from the McMurray formation of northeastern Alberta, *Unio hamili* McLearn from the lower Blairmore formation of southwestern Alberta, and *Unio douglassi* Stanton from the Kootenai formation of central Montana. It is here regarded as a distinct genus. *Pleisielliptio* Russell, with which it is connected by closely related species (some of the species referred to each group having a pair of narrowly divergent raised lines posterodorsally), should probably be regarded as a subgenus of *Protelliptio*. The species of *Protelliptio* have medium-sized shells, elongate ovoid in shape with low beaks and numerous regular concentric undulations extending well down on the disc. The posterodorsal region was described as usually marked by radiating, upcurved, *Lasmigona*-like plications. This character is best developed in the type but probably reaches a minimum in *P. hamili* and the new subspecies here described.

PROTELLIPTIO HAMILI EUREKENSIS MacNeil, n. subsp.
Plate 37, figures 1–3

This form compares almost exactly in shape with typical *P. hamili*, differing mainly in the uniformity of the concentric undulations, which do not appear to become as irregular or to assume as posterior a strike after crossing the umbonal ridge. None of the available specimens show any indication of the *Lasmigona*-like plications.

Holotype (U. S. Nat. Mus. no. 76098), a specimen somewhat distorted posteriorly, measures, length 41 mm, height 21 mm. If undistorted it would measure about 46 mm or more in length. Paratypes, U. S. Nat Mus. nos. 76099, 76116.

Family SPHAERIIDAE
Genus MUSCULIOPSIS MacNeil, n. gen.

Genotype, *Musculiopsis russelli* MacNeil, n. sp. Lower Cretaceous, Eureka district, Nevada.

Shell moderately small and subquadrate. Beaks situated near the anterior third of the shell. Umbones moderately high and prominent. Umbonal ridge moderately to weakly carinate in young shells but usually rounded in adults. Hinge of the left valve consisting of two cardinal teeth, a moderately heavy wedge-shaped one anteriorly ("2" of Bernard's hinge formula), directed slightly to the posterior, and a thinner, nearly horizontal one (4b) posterior to it. The right valve bears a continuous bifid cardinal tooth, the posterior leg of which (3b) inserts between the two teeth of the left valve, and the anterior leg (3a) lies anterior to the large tooth of the left valve. Lateral teeth also well developed, single in the left valve, the posterior thin and elongate, the anterior shorter and heavier. Laterals not seen in the right valve, but supposedly double.

This genus has essentially the same type of hinge as *Sphaerium* and *Musculium* but differs primarily in the strength of the hinge, especially in the heavy, wedge-shaped, posteriorly directed anterior cardinal (2) in the left valve. *Musculiopsis* has decidedly more prominent and prosogyrate beaks than other genera of Sphaeriidae, and is as much in contrast with their Cre-

taceous representatives as with the Recent forms. *Murraia* Russell from the Lower Cretaceous of northeastern Alberta is not regarded as closely related. Russell has placed the latter genus in both the Unionidae and Mutelidae but has not stated whether the shell is pearly or non-nacreous, if such a detail can be determined.

MUSCULIOPSIS RUSSELLI
MacNeil, n. sp.
Plate 37, figures 4–7

Shell thin and moderately inflated; anterior margin rather sharply rounded, ventral more broadly rounded, posterior nearly straight but becoming sharply rounded posteroventrally; dorsal margin higher behind the beaks than before, producing a well defined and depressed lunular area; umbonal ridge moderately sharp in young shells; posterior slope slightly concave in juvenile shell; sculpture consisting of fine concentric raised growth lines; shell not uniformly formed but frequently with one or two wavy constrictions, strongest in the region of the umbonal ridge; hinge as described for the genus.

Holotype (U. S. Nat. Mus. no. 76100) measures, length 15.5 mm, height 9.5 mm, convexity 4 mm; paratype (76101), length 11.5 mm, height 8.5 mm, convexity 2.5 mm; other paratypes, 76114, 76115.

The species described by McLearn as *Corbula? onestae* from the lower Blairmore formation of southeastern Alberta is closely related to *M. russelli* and is the only other species known to me that I can confidently place in *Musculiopsis*. The Eureka species differs from *M. onestae* in having somewhat more central beaks, so that the anterior end of the shell has the appearance of being sharper and more elongate. Other differences are not obvious from a mere comparison with the published figures.

The correlation of the fresh-water beds of the Eureka district with the lower Blairmore formation is based on the similarity of the pelecypods just described. The unionids are so closely related as to be of subspecific difference at best. The sphaerids are likewise closely related, the species involved being the only two at present referable to the peculiar sphaerid genus *Musculiopsis* here described.

Class GASTROPODA
Subclass STREPTONEURA
Order PECTINIBRANCHIA
Family VIVIPARIDAE

Genus SCALEZ Hanna and Gaylord, 1924

Scalez HANNA and GAYLORD, *1924*, California Acad. Sci., Proc., ser. 4, vol. 13, pp. 147–149, 2 text figs.

Woodring (1926, 1932) in several discussions of the calcareous, *Viviparus*-like opercula from the Etchegoin formation of California, described by Hanna and Gaylord as *Scalez petrolia*, mentioned similar opercula from Eureka, Nevada, along with others from the Upper Cretaceous and Eocene and suggested that all represent at least the same generic type, probably an extinct genus of Viviparidae. A restudy of the opercula in question revealed some remarkable structural features which it is thought desirable to describe in detail, and which show with reasonable certainty that all are congeneric. Further search through the Cretaceous collections in the U. S. National Museum revealed several more of these calcareous opercula, usually associated with *Viviparus*-like shells, and one specimen of "*Viviparus*" *montanensis* Stanton from the Kootenai formation of Lower Cretaceous age near Harlowton, Montana, with a calcareous operculum in place. Future work may show that many, if not most, of the species of *Viviparus* described from the western interior and Rocky Mountain regions are really referable to this extinct genus.

Previous references to the operculum of *Scalez* have not adequately described it, but owing to its unusual structure and the fact that the shell is not readily distinguishable from that of *Viviparus*, it may always be necessary to obtain the operculum in order to determine the genus with certainty.

The operculum of *Scalez* is characterized by an internal callus, which, instead of being amorphous as in *Ampullaria* and *Bythinia*, is perfectly spiral at the center but becomes concentric after a variable number of turns, ranging from half a turn in the genotype to five or more in the older species. The spiral on the callus is right-handed, as viewed from the inside, thus differing from the nucleus of the operculum proper, exemplified by

that of *S. powelli*, which, as in all other right-handed shells in which it is present is right-handed as viewed from the outside. Thus the two spirals, the spiral on the callus and the nucleus of the operculum, revolve in opposite directions.

The known range of *Scalez* is now Lower Cretaceous to Pliocene. It is represented by *Scalez powelli* (Walcott) in the unnamed Lower Cretaceous formation in the Eureka district of Nevada, and by *Scalez montanensis* (Stanton) in the equivalent Kootenai formation near Harlowton, Montana. Opercula have been found at three localities in Montana in the Judith River formation of Upper Cretaceous age: On Dog Creek, a tributary of the Judith River (fig. 19); on Cow Creek about 30 miles east-northeast of the mouth of Judith River; and at the mouth of Meili Coulee, near Havre. From the basal Eocene, opercula (fig. 20) have been collected from the Fort Union formation in the Eagle Coal Mine at Bear Creek, Montana, a locality famous for fossil mammals. Thus far no specimens known to me have been found in the Tertiary between the Fort Union horizon and the Pliocene Etchegoin formation of California. The possibility remains that the genus will still be found in some isolated or unprospected Recent lake or stream.

SCALEZ POWELLI (Walcott)

Plate 37, figures 10, 11, 21, 22

Ampullaria? powelli WALCOTT, *1883*, Science, vol. 2, p. 808, figs. 3, 3a. WALCOTT, *1884*, U. S. Geol. Survey, Mon. 8, p. 261, figs. 4, 5. HENDERSON, *1935*, Geol. Soc. America, Special Paper 3, p. 188. (Contains a complete synonymy.)

The discovery of a calcareous operculum in the aperture of a specimen of "*Viviparus*" *montanensis* (Stanton) similar to the opercula from Eureka believed by Walcott to belong to his *Ampullaria? powelli* makes it fairly certain that Walcott's attribution of the species is correct, although the presence of another, higher-spired gastropod and another operculum with a considerably more central nucleus (pl. 37, fig. 18) in the Walcott collection might have made this uncertain. *Scalez powelli* is much like *S. montanensis* in both shape and size and the approximate age equivalence of the two makes it probable that they are closely related, if not the same species.

The opercula of *S. powelli* are elongate-ovate in shape with the inner edge straighter and the upper-inner region somewhat attenuated. The outside is concave and marked by well defined concentric growth lines. A small nucleus is located about midway between the center of the operculum and the inner margin. From the nucleus to the attenuated tip is a well-developed crease, hidden internally by the callus but visible when the callus is removed (pl. 37, fig. 21). Internally the operculum, when entire (though it frequently is found without the callus), bears a callus which begins as a perfect right-hand spiral, but which after three to five turns becomes perfectly concentric. Outside the callus is the smooth inner surface of the operculum. When the callus is removed mechanically, however, there is found under it a rapidly expanding left-handed paucispiral nucleus. The directions of the spiral callus and nucleus just described are as viewed from within, so that, actually, if viewed from without, the nucleus turns to the right, just as it does in all right-handed shells. The concentric rings toward the inner edge of the operculum are more crowded than on the outer edge.

Opercula from the Judith River and Fort Union formations are similar to the Eureka opercula in outline, but somewhat saddle-shaped. The callus is somewhat depressed, having the appearance of being neatly inlaid rather than plastered on the interior. The crease extending from the nucleus to the tip is weak or absent. The callus is spiralled for about five or six volutions. The last spirals and the concentric rings are much more crowded on the inner side than in the Eureka specimens, and the narrow inner strip of the operculum either resorbs the outermost or covers them so that they have the appearance of entering at one end and emerging at the other (pl. 37, figs. 19, 20). No evidence of the paucispiral nucleus was observed, either on specimens on which the callus is shed, or on prepared specimens. A peculiarity observed on several specimens was the presence of two or even three spirals at the center of the callus that overlapped each other but were followed by concentric

rings at a certain stage, just as in the case of the more-normal single spiral.

Specimens of *Scalez petrolia* in the U. S. National Museum are similar to the Judith River form in shape but are considerably more concave exteriorly, so that the callus is elevated rather than depressed. The callus is not multispiral, but after a small spiral of less than a full turn becomes perfectly concentric. One specimen examined has two overlapping spirals at the center similar to those of some of the Judith River specimens. The concentric rings are even more cut off on the inner side as they reach the inner margin.

One interesting feature in the evolution of the *Scalez* operculum, assuming, of course, that the known species represent some sort of a linear series, is the early loss of the spiral nucleus.

Lectotype, U. S. Nat. Mus. no. 76102; paratype 76103. Opercula; with callus, U. S. Nat. Mus. no. 76105, without callus, 76106. The largest specimen measured has a length of 8 mm. Specimen from Judith River formation, Dog Creek, Montana, 29745, largest specimen measures 12 mm. Specimen from Fort Union formation, Bear Creek, Montana, 76108.

VIVIPARID? sp.

Plate 37, figures 8, 9

Several specimens, too imperfect for diagnosis, of a high-spired viviparidlike shell occur in the same matrix that contains the operculum with the more central nucleus (pl. 37, fig. 18) and the two may represent the same species.

Figured specimens, U. S. Nat. Mus. no. 76104, 76117.

Subclass EUTHYNEURA

Order PULMONATA

Family ELLOBIIDAE

Genus ZAPTYCHIUS Walcott

ZAPTYCHIUS CARBONARIUS Walcott

Plate 37, figure 12

Zaptychius carbonaria WALCOTT, *1883*, Science, vol. 2, p. 808, fig. 1.—WALCOTT, *1884*, U. S. Geol. Survey, Mon. 8, p. 263, fig. 7.—HENDERSON, *1935*, Geol. Soc. America, Special Paper 3, p. 231. (Contains a complete synonymy.)

It would be desirable to know this species better, the type being fragmental and much eroded. *Zaptychius* is probably correctly assigned to the Ellobiidae (=Auriculidae) on the basis of its aperture, but it is considerably more slender and higher than other members of the family. Possibly the nearest known fossil relative of this species in North America is *"Auricula" neumayri* White from the Bear River formation of Wyoming, of Upper Cretaceous age, but *A. neumayri* is short and inflated, with a short spire, and the upper tooth in the aperture points noticeably downward rather than slightly upward, as in *Z. carbonarius*. The specific name of the Eureka species seems unfortunate, for it now proves to be of Cretaceous age rather than Carboniferous.

Holotype (specimen bearing this previously assigned number so regarded), U. S. Nat. Mus. no. 33305.

Family PHYSIDAE

Genus PHYSA Draparnaud

PHYSA PRISCA Walcott

Plate 37, figure 15

Physa prisca WALCOTT, *1883*, Science, vol. 2, p. 808, fig. 2.—WALCOTT, *1884*, U. S. Geol. Survey, Mon. 8, p. 262, fig. 6.—HENDERSON, *1935*, Geol. Soc. America, Special Paper 3, p. 261. (Contains a complete synonymy.)

Like the preceding this species is represented by poor material, and it is doubtful if it could be recognized outside the type locality. Walcott reported the largest specimen seen by him to be 9 mm high but another specimen in the Walcott collection is slightly over 15 mm high.

Holotype (specimen bearing this previously assigned number so regarded), U. S. Nat. Mus. no. 33304.

Genus APLEXA Fleming

APLEXA MORRISONI MacNeil, n. sp.

Plate 37, figures 13, 14

Shell extremely slender and elongate; whorls about five or six; spire considerably longer than the aperture; aperture not well exposed on type but apparently narrow and elongated; surface marked by *Lymnaea*-like growth lines and by a slight revolving depressed line below the suture.

Holotype (U. S. Nat. Mus. no. 76110) measures, height 18 mm, width 4.5 mm; paratype, 76111.

This species is much more slender and elongate than any Recent species of *Aplexa*, and the sculpture consists of fine raised growth lines similar to those of *Lymnaea*. In most Recent *Aplexa* the shell is quite smooth. *Aplexa morrisoni* is probably related to *A. macerata* Russell from the Foremost beds of Upper Cretaceous age of southern Alberta, a species described by Russell as the most attenuated species known to him. The Eureka species is somewhat smaller than *A. macerata* and even more slender. Judging from Russell's figures, *A. macerata* appears to be more closely related to *A. atava* (White) from the Judith River formation at Dog Creek, Montana, than to the species here described.

Family LANCIDAE

Genus LANX Clessin

LANX NEVADENSIS Mac Neil, n. sp.

Plate 37, figures 16, 17

Shell large, broadly subcircular, anterior end somewhat flattened, little inflated; apex just behind center, slightly inclined; concentric growth lines rather prominent and becoming fine concentric ridges in adult stages.

Holotype (U. S. Nat. Mus. no. 76112) measures about 15 mm in both length and width, height 4.5 mm; paratype 76113.

Outside of the record by Whiteaves of the occurrence of the small Fort Union species, *Ancylus* (*Acroloxus*) *minutus* (Meek and Hayden), in the Cretaceous of Canada, this is the first of the fresh-water limpets to be reported from the Cretaceous of North America.

Lanx nevadensis is nearly the same size as *L. undulatus* (Meek) from the lower and middle Tertiary of Nevada but is more circular, lower, and does not have the undulations on the foreslope and sides. The type, *Lanx newberryi* (Lea), Recent from California, is higher and narrower with smoother sculpture.

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NOTE: Published by permission of the Director of the U. S. Geological Survey. Manuscript received by the Editor January 17, 1939.

EXPLANATION OF PLATE 37

FIGS. *1–3—Protelliptio hamili eurekensis* MacNeil, n. subsp. *1*, Squeeze of holotype ×1, U. S. N. M. 76098; *2*, paratype, ×3, squeeze showing beak sculpture, 76099; *3*, paratype, ×1, 76116. (p. 356)

4–7—Musculiopsis russelli MacNeil, n. sp. *4*, Holotype, ×3, U. S. N. M. 76100; *5*, paratype, ×3, 76101; *6*, paratype, ×4, hinge of right valve, 76114; *7*, paratype, ×3, hinge of left valve, 76115. (p. 357)

8, 9—Viviparid? *8*, ×2, U. S. N. M. 76104; *9*, ×3, 76117. (p. 359)

10, 11, 21, 22—Scalez powelli (Walcott). *10*, Lectotype, ×4, U. S. N. M. 76102; *11*, paratype, ×3, 76103; *21*, inside of operculum, ×8, callus removed, 76106; *22*, inside of operculum, ×8, with callus, 76105. (p. 358)

12—Zaptychius carbonarius Walcott. Holotype, ×6, U. S. N. M. 33305. (p. 359)

13, 14—Aplexa morrisoni MacNeil, n. sp. *13*, Paratype, ×2, U. S. N. M. 76111; *14*, holotype, ×2, 76110. (p. 359)

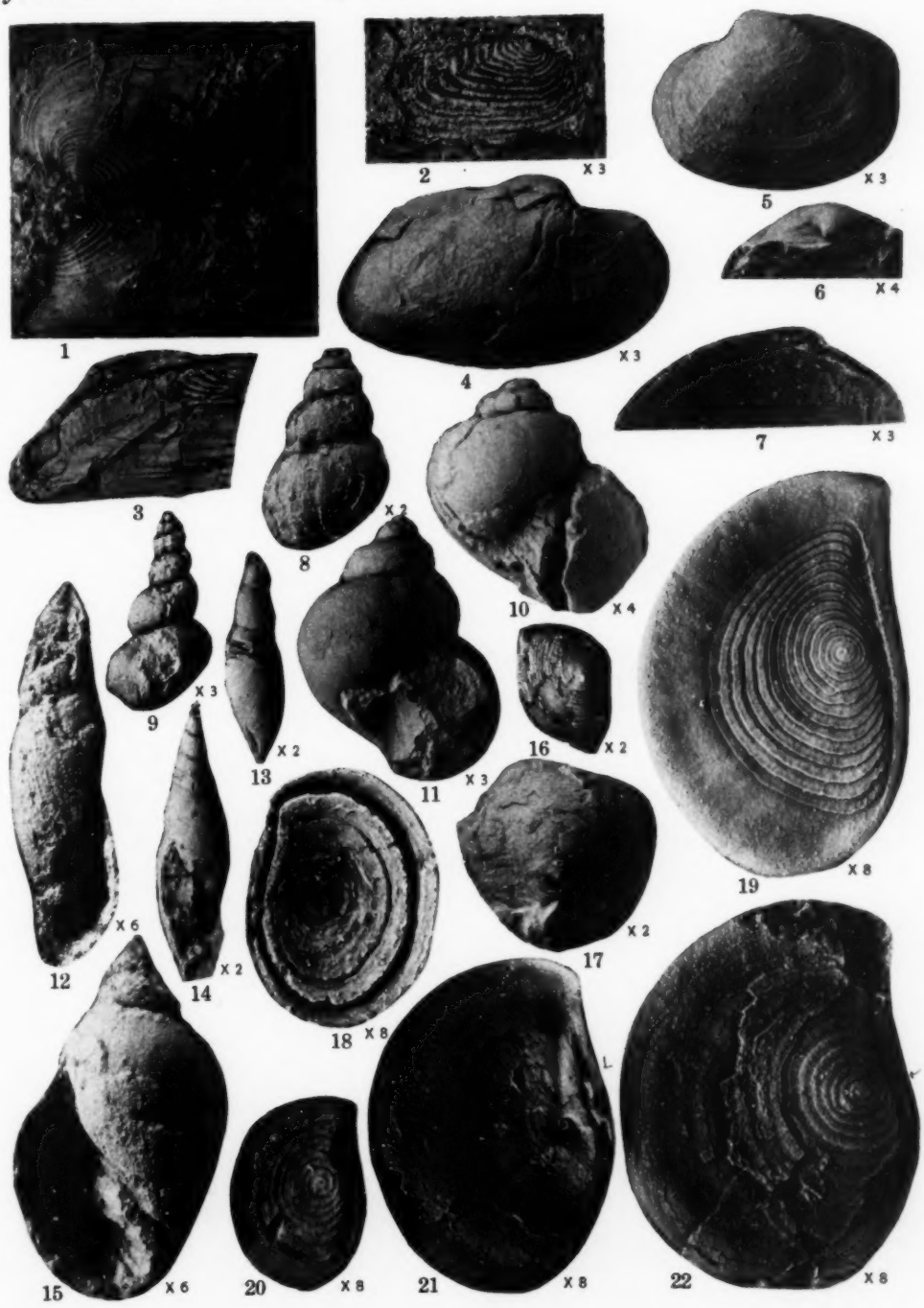
15—Physa prisca Walcott. Holotype, ×6, U. S. N. M. 33304. (p. 359)

16, 17—Lanx nevadensis MacNeil, n. sp. *16*, Paratype, ×2, U. S. N. M. 76113; *17*, holotype, ×2, 76112.

18—Viviparid? Operculum, specimen with large, nearly central nucleus, ×8, U. S. N. M. 76107. Possibly species represented by *8* and *9*. (p. 359)

19—Scalez sp. Operculum from Judith River formation, Dog Creek, Montana, ×8, U. S. N. M. 29745. (p. 358)

20—Scalez sp. Operculum from Fort Union formation, Eagle Coal Mine, Bear Creek, Montana, ×8, U. S. N. M. 76108. (p. 358)



MacNeil, Cretaceous Mollusks

Fig. 1—Rock ledge from Burton quarry (now removed to Custer State Park), showing dinosaur tracks, ripple marks, and shrinkage cracks in Lakota sandstone.

Fig. 2—Dinosaur tracks on block of Lakota sandstone, Grace Coolidge Creek.

Anderson, Dinosaur Tracks

JOURNAL OF PALEONTOLOGY, VOL. 13, NO. 3, PP. 361–364, PL. 38, 2 TEXT FIGS., MAY, 1939

DINOSAUR TRACKS IN THE LAKOTA SANDSTONE OF THE EASTERN BLACK HILLS, SOUTH DAKOTA

SUMNER M. ANDERSON
National Park Service, Anna, Illinois

ABSTRACT—Two heretofore undescribed groups of dinosaur tracks are reported from the Lakota sandstone formation near Rapid City, South Dakota. Seven to nine individuals of probably a single carnivorous species are represented from the small but crowded Burton quarry exposure, now on exhibit at the Custer State Park Museum. The exposures at Grace Coolidge Creek include tracks of at least one additional carnivorous species, one that was probably herbivorous, and two imprints that have not been positively identified with dinosaurs.

DINOSAUR tracks at two sites herein reported have been known locally for several years, but a careful search of the literature has revealed no published description of them. I am indebted to James Bump, Museum Curator at the South Dakota School of Mines, and H. E. Martin, Museum Technician at Custer State Park, for calling attention and directing me to these two sites, and to Dr. E. H. Colbert of the American Museum of Natural History for a critical review of my interpretations and helpful suggestions regarding type identifications. Field observations were made in April and June, 1937, in connection with geological investigations for the National Park Service, in company with Harold Buus, assigned to temporary geological work at Custer State Park, and Mr. Martin.

BURTON QUARRY SITE

About one and one-half miles northwest of the business section of Rapid City is the Burton quarry (at present inoperative) in the Lower Cretaceous Lakota sandstone. The first dinosaur tracks found here were reported in 1917 by O'Harra[1] as follows:

> The footprints were found during the spring of 1912 at the Burton sandstone quarry in the Lakota formation about one and one-half miles northwest of the business section of Rapid City . . . the sandstone is rather coarse grained, and as a consequence the impressions are not as clearly defined as might be desired. Most of the tracks show little detail as to segments.

[1] O'HARRA, C. C., *June 1917*, Fossil footprints in the Black Hills: *Pahasapa Quart.*, vol. 6, pp. 20–29.

All of the tracks described were depressions, and most were about the same size,

> . . . the long toe impression varying from a little less to a little more than one inch.

One large track, only a portion of which was preserved,

> . . . shows a length of about four inches for the longest toe. Apparently there is little from which we can infer the manner of walking or the length of stride, nor does there seem to be any indications of impressions other than those of the feet. In all cases the tracks seem to indicate that the animals making them were tridactyl. I have not been able to detect the nature of the gait other than it seems to be bipedal. The conditions under which the tracks were made can only be conjectured. They occur in the Lakota formation at a horizon approximately 60 feet above the base. The Lakota in this portion of the Black Hills is of varying thickness and in the locality where the foot-prints occur reaches approximately 200 feet. Many of the layers show cross bedding and some of them are beautifully ripple-marked. The surfaces containing footprints show occasionally what is apparently a slight tendency toward ripple marking but in general they are not characterized by marks of any particular significance. No footprints were observed on the unmistakably ripple-marked surfaces. Just as Triassic reptiles wandered along the shores of the old Connecticut embayment, so here dinosaurs or their near relatives frequented the sandy shores at the Lakota sea or bay in search of food or company, and the yielding surface aided by the incoming tides preserved their footprints for the ages to come.

Some or probably all of the prints described by O'Harra were collected for display in the museum at the South Dakota School of Mines, and no prints fitting the description as to size and horizon are evident in place today. However at the same site but lower down in the formation subse-

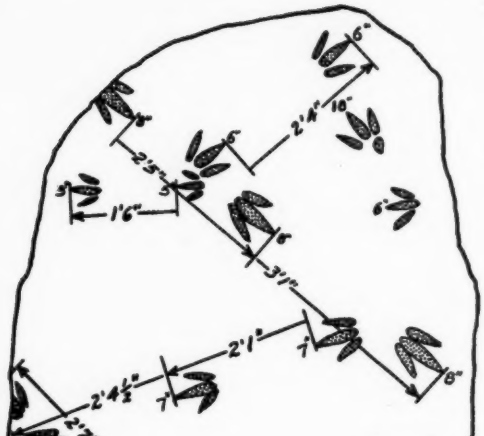


FIG. 1—Sketch diagram of dinosaur tracks in ledge of Lakota sandstone at Burton quarry, 1½ miles northwest of Rapid City, South Dakota. Figures with arrows show length and direction of stride. Figure in front of each track indicates length of middle toe. Twenty-two tracks, including partial tracks, were counted on this 6½ by 11 foot slab.

quent quarrying has uncovered other dinosaur footprints. The tracks now exposed are in the lower part of the Lakota sandstone at a horizon about 13 feet above the base, which is here underlain by the Unkpapa (Upper Jurassic?) sandstone. At the contact a sharp color change distinguishes the white Unkpapa from the yellowish-brown Lakota above. To O'Harra's description of the Lakota might be added that the individual beds vary from about an inch to three or four feet in thickness. The Lakota here, as observed at the ledge where the tracks were found, strikes north and dips 9° E.

The rock on which the imprints are best displayed is a slab 11 feet long that projected 6½ feet from under an overlying ledge at the floor of the quarry (pl. 38, fig. 1). On this relatively small area 22 tracks, four incomplete, were counted (text fig. 1). The surface of the sandstone slab is distinctly ripple-marked and covered with sand-filled shrinkage cracks, suggesting a beach of an embayment or open shallow sea on which dinosaurs wandered at low tide. The tracks could have been made by no less than seven dinosaurs, for the impressions of the middle toe measure 5, 5½, 6, 6½, 7, 8, and 10 inches in length. On the basis of length of stride however the number of animals represented is more likely eight, as two individuals are probably represented respectively by one set of consecutive 6-inch tracks showing strides of 1 foot 8 inches and 1 foot 10 inches and a second set of tracks of the same size that are 2 feet 4 inches apart. This count disregards an isolated track with a 6-inch middle toe, which may or may not have been made by an additional animal. The largest track, with the 10-inch middle toe, is also isolated, with length of stride consequently undeterminable. The shortest stride, 1 foot 6 inches was made by the reptile with the shortest middle toe, 5 inches, and the longest measurable stride of 3 feet 1 inch was made by the reptile with the second longest, or 8-inch middle toe. This relationship is not consistent throughout, however, for length of stride naturally varies, as with other animals, not only between individuals but with any given individual relative to varying gait. This is illustrated by the following comparative measurements, which show a general relationship but no fixed proportion between length of stride and the size of the foot:

LENGTH OF MIDDLE TOE	LENGTH OF STRIDE
5 inches	1 foot 6 inches
5½ inches	2 feet 0 inches
6 inches	1 foot 8 inches
	1 foot 10 inches
6 inches	2 feet 4 inches
6 inches	Isolated print
6½ inches	2 feet 7 inches
7 inches	2 feet 1 inch
	2 feet 4½ inches
8 inches	2 feet 5 inches
	3 feet 1 inch
10 inches	Isolated print

The tracks with the 5½-inch middle toe span 6 inches from the tip of the outer to the tip of the inner toe. Some of the other tracks measured as follows: middle toe 6½ inches, span 7½ inches; middle toe 6½ inches, span 8 inches; middle toe 8 inches, span 8½ inches. One track measures 10 inches from the tip of the 6½-inch middle toe to the back of a rather clearly marked pad impression, and on the largest track 1 foot 2½ inches covers the measurement from the tip of the 10-inch middle toe to the back of a similar impression.

From the above observations, detailed conclusions regarding the type or types of dinosaurs responsible for the tracks are difficult to make. None of the animals left any impressions other than those of the feet. All were tridactyl and bipedal as to the manner of walking, and the impression of pads in two of the tracks suggests that they were semiplantigrade; that is, they walked on the toes, as shown by the majority of the tracks, but settled on the pads of the feet while resting. None of the tracks show details as to segments. Their rather sharp points suggest that the toes were equipped with claws, a characteristic of carnivores. The narrow tread revealed by the alignment of the tracks in series indicates that locomotion was accomplished with the legs well under the body and with one foot in front of the other, similar to the gait of large running birds such as the ostrich. Consequently the hind legs were undoubtedly long in relation to the rest of the body, and it may be reasoned by analogy with skeletal remains of dinosaurs having those characteristics that the fore limbs were short with "hands" used primarily for grasping and holding. The dinosaurs here represented may be considered as from small to moderate size, the largest probably being unable to reach more than 10 feet high when in upright position. This estimate is based on the assumption that a stride of 3 feet would probably be made by legs no more than 5 feet long, or roughly one-half the height of a long-necked dinosaur such as a Coelurusaur or a small Camptosaur or a related form. While suggesting these comparisons it may be pointed out that if Coelurusaurs walked these sands they failed to leave the slight imprint that might be expected of their fourth rudimentary toe, and that Camptosaurs have not yet been reported from any beds later than the Morrison.

Mrs. Anna R. Burton, owner of the quarry, granted permission to the South Dakota School of Mines to collect from this site. The School of Mines, in turn, granted permission to the Park Service to collect the slab herein described, and during the summer of 1937 this slab, weighing approximately 4½ tons, was removed to the terrace outside the Custer State Park Museum, where it is now on exhibit.

GRACE COOLIDGE CREEK SITE

The second site examined is on Grace Coolidge Creek (formerly Squaw Creek), five miles by road or two and three-quarters miles in a straight line S. 60° W. of Hermosa, South Dakota. The lower Lakota sandstone here forms a cliff that rises abruptly for about 60 feet on the south side of the creek. On the north side and roughly a quarter of a mile east the extension of the same beds are underlain by Morrison shale of upper Jurrassic age, exposed in a road cut.

Broken from the cliff face and lying at its base are huge blocks of sandstone, with dimensions as great as approximately 10 feet thick, 12 feet wide, and 18 feet long. These blocks lie nearly on edge. On the bedding surfaces are revealed several dinosaur tracks. As a careful search of the ledges in the adjacent cliff failed to disclose any tracks in place, the exact horizon at which they were formed was impossible to determine, but it is believed to lie somewhere between 10 and 70 feet above the base of the Lakota formation.

Lithologically the sandstone here is not appreciably different from that previously described, although of a slightly darker brown color. The imprinted surfaces, however, show no signs of ripple markings or shrinkage cracks such as are so prominent at Burton quarry. The clear-cut outlines and depth of the tracks indicate that the sand was moist at the time the tracks were made.

The dinosaurs that made the tracks were of several different sizes and species, apparently none of which were the same as represented at the Burton quarry site, as the toe prints are of a different shape.

FIG. 2—Dinosaur tracks in block of Lakota sandstone, Grace Coolidge Creek.

Tracks 1 (a fragment) and 2 in plate 38, figure 2 appear to have been made by a single plantigrade animal with a 2½-foot stride, probably herbivorous and of considerable bulk. To support this bulk the feet in bipedal progression were spread apart somewhat, in contrast to the nearly straight-line foot-placing of the lighter carnivores. Track number 2 measures 1 foot 4 inches from the tip of the middle toe to the back of the pad, and 1 foot 1 inch from the tip of the inner to the tip of the outer toe.

Track 3 (pl. 38, fig. 2), is not very clearly defined but seems suggestive of a partly-webbed foot. The 5½-inch toe spread is greater than the 5-inch total length of the track. Neither this nor track 4 have been positively identified with dinosaurs. Track 4, with a 6-inch length and 5-inch spread, has digital angles exceptionally large for either the hind or fore feet of dinosaurs, and it may have been made by a more or less closely related reptile or conceivably even by a primitive bird.

Number 5 (pl. 38, fig. 2) marks one of several pad-shaped rock casts on this and an adjoining block. Their relative positions and uniform size suggest fillings of tracks in soft sand, but one that was pried off and broken open failed to reveal any definite outlines of foot marks.

The large track in text figure 2 differs from all the others photographed. The middle toe is about 8 inches long and the distance from its tip to the back of the pad is 18 inches. Possibly the dinosaur that made it was semiplatigrade and was resting at the time. The long narrow toes were equipped with claws and must have belonged to a carnivore of considerable size.

The small track in text figure 2, also suggestive of a carnivore, could not be reached for measurement but by comparison with the hammer appears to have about 5 inches of middle toe showing and an approximate spread of 7 inches. It might be the fore-foot impression of the same individual responsible for the large track beside it, or it might be either the fore- or hind-foot impression of an individual of an entirely different species.

Lack of data on length of stride precludes establishment of any very enlightening conclusions regarding the nature of the dinosaurs that left these isolated footprints.

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PHLAOCYON—A CORRECTION

PAUL O. McGREW

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DR. JOHN CLARK has been so kind as to call my attention to a misstatement in a paper on the dental morphology of the Procyonidae (McGrew, 1938).

On page 337 of this paper I stated that

Phlaocyon (and probably *Aletocyon*) certainly cannot be ancestral to *Ailuropoda* since it had already lost M_3^-, but this would not bar it from the ancestry of *Ailurus*.

The error lies in the fact that *Phlaocyon* (and therefore probably *Aletocyon*) definitely does have an M_3^-. How this mistake came to be committed I do not know; Matthew's (1902) figure plainly shows M_3^- in place. At any rate, the above conclusion must be altered and *Phlaocyon* may be tentatively regarded, not only as a structural ancestor of *Ailurus* but also of *Ailuropoda*.

My major conclusion, however, that *Phlaocyon* is not ancestral to *Procyon*, and belongs with the Cynarctinae is, of course, further supported by its retention of M_3^-.

It is also desirable to call attention to an opinion expressed in an earlier paper on *Cynarctus* in which I stated (McGrew, 1937) that

Bassaricyon, *Nasua* and *Potos* were obviously derived from some early ancestral procyonid, but at what stage they made their departure from the known lines of descent cannot be determined at present. *Euprocyon* is closely related to *Procyon* and is probably of relatively recent origin.

Nasua[1] appears to be structurally much closer to *Procyon* than I originally thought and is probably of as recent origin as *Euprocyon*.

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——, *1938*, Dental morphology of the Procyonidae with a description of *Cynarctoides*, gen. nov.: *Field Mus. Nat. History, Geol. Ser.*, vol. 6, pp. 323–329.

[1] My attention was directed to this by Mr. D. Dwight Davis who is at present engaged in extensive studies of the procyonids, pandas and ursids.

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*Sinclair, W. J. Died Mar. 25, 1935.
Slocum, Arthur W. Died Nov. 20, 1937.
*Springer, Frank. Died Sept. 22, 1927.
Tegland, Nellie M. Died Dec., 1930.
Teller, Edgar E. Died July 19, 1923.
*Thomas, A. O. Died Jan. 13, 1931.
*Tilton, J. L. Died Nov. 17, 1930.
*Twitchell, G. B. Died Apr. 28, 1933.
*Twitchell, M. W. Died Apr. 8, 1927.
*Van Ingen, Gilbert. Died July 7, 1925.
*Vodges, Anthony W. Died Feb. 8, 1923.
*Walcott, Charles D. Died Feb. 9, 1927.
*Waring, Charles A. Died Nov. 5, 1918.
*Weinzierl, Mrs. J. F.
*Weller, Stuart. Died Aug. 5, 1927.
*White, David. Died Feb. 7, 1935.
*Williams, Henry S. Died July 31, 1918.
Williston, S. W. Died Aug. 30, 1918.
Wilson, Herrick E. Died Jan. 24, 1925.
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